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## RADICALISM, CONSERVATISM, AND THE TRANSITION OF INSTITUTIONS.[1]

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OF readers who have accompanied me thus far, probably some think that the contents of these papers go beyond the limits implied by their title. Under the head *Study of Sociology*, so many sociological questions have been incidentally discussed, that the science itself has been in a measure dealt with while dealing with the study of it. Admitting this criticism, my excuse must be that the fault, if it is one, has been scarcely avoidable. Nothing to much purpose can be said about the study of any science without saying a good deal about the general and special truths it includes, or what the expositor holds to be truths. To write an essay on the study of astronomy, in which there should be no direct or implied conviction respecting the Copernican theory of the solar system, nor any such recognition of the law of gravitation as involved acceptance or rejection of it, would be a task difficult to execute, and, when executed, probably of little value. Similarly with Sociology—it is next to impossible for the writer who points out the way toward its truths to exclude all tacit or avowed expressions of opinion about those truths, and, were it possible to exclude such expressions of opinion, it would be at the cost of those illustrations needed to make his exposition effective.

Such must be, in part, my defense for having set down many thoughts which the title of this work does not cover. Especially have I found myself obliged thus to transgress, by representing the study of sociology as the study of evolution in its most complex form. It is clear that, to one who considers the facts societies exhibit as having had their origin in supernatural interpositions, or in the wills of individual ruling men, the study of these facts will have an aspect wholly unlike that which it has to one who contemplates them as gen-

[1] Concluding article of the series on the "Study of Sociology."

erated by processes of growth and development continuing through centuries. Ignoring, as the first view tacitly does, that conformity to law, in the scientific sense of the word, which the second view tacitly asserts, there can be but little community between the methods of inquiry proper to them respectively. Continuous causation, which in the one case there is little or no tendency to trace, becomes, in the other case, the chief object of attention; whence it follows that there must be formed wholly different ideas of the appropriate modes of investigation. A foregone conclusion respecting the nature of social phenomena is thus inevitably implied in any suggestions for the study of them.

While, however, it must be admitted that throughout these articles there runs the assumption that the facts, simultaneous and successive, which societies present, have a genesis no less natural than the genesis of facts of all other classes, it is not admitted that this assumption was made unawares, or without warrant. At the outset, the grounds for it were examined. The notion, widely accepted in name, though not consistently acted upon, that social phenomena differ from phenomena of most other kinds, as being under special providence, we found to be entirely discredited by its expositors; nor, when closely looked into, did the great-man-theory of social affairs prove to be more tenable. Besides finding that both these views, rooted as they are in the ways of thinking natural to primitive men, would not bear criticism, we found that even their defenders continually betrayed their beliefs in the production of social changes by natural causes—tacitly admitted that after certain antecedents certain consequents are to be expected—tacitly admitted, therefore, that some prevision is possible, and therefore some subject-matter for science.

From these negative justifications for the belief that sociology is a science, we turned to the positive justifications. We found that every aggregate of units, of any order, has certain traits necessarily determined by the properties of its units. Hence it was inferable, *a priori*, that, given the natures of the men who are their units, and certain characters in the societies formed are predetermined—other characters being determined by the coöperation of surrounding conditions. The current assertion, that sociology is not possible, implies a misconception of its nature. Using the analogy supplied by a human life, we saw that just as bodily development, and structure, and function, furnish subject-matter for biological science, though the events set forth by the biographer go beyond its range, so, social growth, and the rise of structures and functions accompanying it, furnish subject-matter for a science of society, though the facts with which historians fill their pages mostly yield no material for science. Thus conceiving the scope of the science, we saw, on comparing rudimentary societies with one another, and with societies in different stages of progress, that they *do* present certain common traits of structure and of function, as well

as certain common traits of development. Further comparisons, similarly made, opened large questions, such as that of the relation between social growth and organization, which form parts of this same science—questions of transcendent importance, compared with those occupying the minds of politicians and writers of history.

The difficulties of the Social Science next drew our attention. We saw that in this case, though in no other case, the facts to be observed and generalized by the student are exhibited by an aggregate of which he forms a part. In his capacity of inquirer, he should have no inclination toward one or other conclusion respecting the phenomena to be generalized; but, in his capacity of citizen, helped to live by the life of his society, embedded in its structures, sharing in its activities, breathing its atmosphere of thought and sentiment, he is partially coerced into such views as favor harmonious coöperation with his fellow-citizens. Hence immense obstacles to the social science, unparalleled by those standing in the way of any other science.

From considering thus generally these causes of error, we turned to consider them specially. Under the head of Objective Difficulties, we glanced at those many ways in which evidence collected by the sociological inquirer is vitiated. That extreme untrustworthiness of witnesses which results from carelessness, or fanaticism, or self-interest, was illustrated; and we saw that, in addition to the perversions of statement hence arising, there are others which arise from the tendency there is for some kinds of evidence to draw attention, while evidence of opposite kinds, much larger in quantity, draws no attention. Further, it was shown that the nature of sociological facts, each of which is not observable in a single object or act, but is reached only through registration and comparison of many objects and acts, makes the perception of them harder than that of other facts. It was pointed out that the wide distribution of social phenomena in space greatly hinders true apprehensions of them; and it was also pointed out that another impediment, even still greater, is consequent on their distribution in time—a distribution such that many of the facts to be dealt with take centuries to unfold, and can be grasped only by combining in thought multitudinous changes that are slow, involved, and not easy to trace.

Beyond these difficulties which we grouped as distinguishing the science itself, objectively considered, we saw that there are other difficulties, conveniently to be grouped as subjective, which are also great. For the interpretation of human conduct as socially displayed, every one is compelled to use, as a key, his own nature—ascribing to others thoughts and feelings like his own; and yet, while this automorphic interpretation is indispensable, it is necessarily more or less misleading. Very generally, too, a subjective difficulty arises from the lack of intellectual faculty complex enough to grasp these social phenom-

ena, which are so extremely involved. And, again, very few have by culture gained that plasticity of faculty requisite for conceiving and accepting those immensely-varied actualities which societies in different times and places display, and those multitudinous possibilities to be inferred from them.

Nor, of subjective difficulties, did these exhaust the list. From the emotional as well as from the intellectual part of the nature, we saw that there arise obstacles. The ways in which beliefs about social affairs are perverted, by intense fears and excited hopes, were pointed out. We noted the feeling of impatience, as another common cause of misjudgment. A contrast was drawn showing, too, what perverse estimates of public events men are led to make by their sympathies and antipathies—how, where their hate has been aroused, they utter unqualified condemnations of ill-deeds for which there was much excuse, while, if their admiration is excited by vast successes, they condone inexcusable ill-deeds immeasurably greater in amount. And we also saw that, among the distortions of judgment caused by the emotions, have to be included those immense ones generated by the sentiment of loyalty to a personal ruler, or to a ruling power otherwise embodied.

These distortions of judgment caused by the emotions, thus indicated generally, we went on to consider specially—treating of them as different forms of bias. Though, during education, understood in a wide sense, many kinds of bias are commenced or given, there is one which our educational system makes especially strong—the double bias in favor of the religions of enmity and of amity. Needful as we found both of these to be, we perceived that among the beliefs about social affairs, prompted now by the one and now by the other, there are glaring incongruities; and that scientific conceptions can be formed only when there is a compromise between the dictates of pure egoism and the dictates of pure altruism, for which they respectively stand.

We observed, next, the warping of opinion which the bias of patriotism causes. Recognizing the truth that the preservation of a society is made possible only by a due amount of patriotic feeling in citizens, we saw that this feeling inevitably disturbs the judgment when comparisons between societies are made, and that the data required for Social Science are thus vitiated; and we saw that the effort to escape this bias, leading as it does to an opposite bias, is apt to vitiate the data in another way. While finding the class-bias to be no less essential, we found that it no less inevitably causes one-sidedness in the conceptions of social affairs. Noting how the various sub-classes have their specialties of prejudice corresponding to their class-interests, we noted, at greater length, how the more general prejudices of the larger and more widely-distinguished classes prevent them from forming balanced judgments. That in politics the bias of party interferes with those calm examinations by which alone the conclusions of Social Science can be reached, scarcely needed pointing out. We observed,

however, that, beyond the political bias under its party-form, there is a more general political bias—the bias toward an exclusively-political view of social affairs, and a corresponding faith in political instrumentalities. As affecting the study of Social Science, this bias was shown to be detrimental as directing the attention too much to the phenomena of social regulation, and excluding from thought the activities regulated, constituting an aggregate of phenomena far more important.

Lastly, we came to the theological bias, which, under its general form and under its special forms, disturbs in various ways our judgments on social questions. Obedience to a supposed divine command being its standard of rectitude, it does not ask concerning any social arrangement whether it conduces to social welfare, so much as whether it conforms to the creed locally established. Hence, in each place and time, those conceptions about public affairs which the theological bias fosters, tend to diverge from the truth in so far as the creed then and there accepted diverges from the truth. And besides the positive evil thus produced, there is a negative evil, due to discouragement of the habit of estimating actions by the results they eventually cause—a habit which the study of Social Science demands.

Having thus contemplated in general and in detail the difficulties of the Social Science, we turned our attention to the preliminary discipline required. Of the conclusions reached so recently, the reader scarcely needs reminding. Study of the sciences in general having been pointed out as the proper means of generating fit habits of thought, it was shown that the sciences especially to be attended to are those treating of Life and of Mind. There can be no understanding of social actions without some knowledge of human nature; there can be no deep knowledge of human nature without some knowledge of the laws of Mind; there can be no adequate knowledge of the laws of Mind without knowledge of the laws of Life. And, that knowledge of the laws of Life, as exhibited in Man, may be properly grasped, attention must be given to the laws of Life in general.

What is to be hoped from such a presentation of difficulties and such a programme of preparatory studies? Who, in drawing his conclusions about public policies, will be made to hesitate by remembering the many obstacles that stand in the way of right judgments? Who will think it needful to fit himself by inquiries so various and so extensive? Who, in short, will be led to doubt any of the inferences he has drawn, or be induced to pause before he draws others, by consciousness of these many liabilities to error arising from want of knowledge, want of discipline, and want of duly-balanced sentiments?

To these questions there can be but the obvious reply—a reply which the foregoing chapters themselves involve—that very little is to be expected. The implication throughout the argument has been that for every society, and for each stage in its evolution, there is an appro-

priate mode of feeling and thinking; and that no mode of feeling and thinking not adapted to its degree of evolution, and to its surroundings, can be permanently established. Though not exactly, still approximately, the average opinion in any age and country is a function of the social structure in that age and country. There may be, as we see during times of revolution, a considerable incongruity between the ideas that become current and the social arrangements which exist, and are, in great measure, appropriate; though even then the incongruity does but mark the need for a readjustment of institutions to character. While, however, those successive compromises, which, during social evolution, have to be made between the changed natures of citizens and the institutions evolved by ancestral citizens, imply disagreements, yet these are but partial and temporary—in those societies, at least, which are developing and not in course of dissolution. For a society to hold together, the institutions that are needed and the conceptions that are generally current must be in tolerable harmony. Hence, it is not to be expected that modes of thinking on social affairs are to be in any considerable degree changed by whatever may be said respecting the Social Science, its difficulties, and the required preparations for studying it.

The only reasonable hope is, that here and there one may be led, in calmer moments, to remember how largely his beliefs about public matters have been made for him by circumstances, and how probable it is that they are either untrue or but partially true. When he reflects on the doubtfulness of the evidence which he generalizes, collected hap-hazard from a narrow area—when he counts up the perverting sentiments fostered in him by education, country, class, party, creed—when, observing those around, he sees that, from other evidence selected to gratify sentiments partially unlike his own, there result unlike views—he may occasionally recollect how largely mere accidents have determined his convictions. Recollecting this, he may be induced to hold these convictions not quite so strongly; may see the need for criticism of them with a view to revision; and, above all, may be somewhat less eager to act in pursuance of them.

While the few to whom a Social Science is conceivable may, to some degree, be thus influenced by what is said concerning the study of it, there can, of course, be no effect on the many to whom such a science seems an absurdity, or an impiety, or both. The feeling ordinarily excited, by the proposal to deal scientifically with these most complex phenomena, is like that which was excited in ancient times by the proposal to deal scientifically with phenomena of simpler kinds. As Mr. Grote writes of Socrates:

"Physics and astronomy, in his opinion, belonged to the divine class of phenomena, in which human research was insane, fruitless, and impious."[1]

[1] "History of Greece," vol. i., p. 498.

And as he elsewhere writes respecting the attitude of the Greek mind in general:

"In his" (the early Greek's) "view, the description of the sun, as given in a modern astronomical treatise, would have appeared not merely absurd, but repulsive and impious: even in later times, when the positive spirit of inquiry had made considerable progress, Anaxagoras and other astronomers incurred the charge of blasphemy for dispersonifying Hêlios, and trying to assign invariable laws to the solar phenomena."[1]

That a likeness exists between the feeling then displayed respecting phenomena of inorganic Nature and the feeling now displayed respecting phenomena of Life and Society, is manifest. The ascription of social actions and political events entirely to natural causes, thus leaving out Providence as a factor, seems, to the religious mind of our day, as seemed to the mind of the pious Greek the dispersonification of Hêlios and the interpretation of the celestial motions otherwise than by immediate divine agency. As was said by Mr. Gladstone, in a speech made shortly after the publication of the second chapter of this volume:

"I lately read a discussion on the manner in which the raising up of particular individuals occasionally occurs in great crises of human history, as if some sacred, invisible power had raised them up and placed them in particular positions for special purposes. The writer says that they are not uniform, but admits that they are common—so common and so remarkable that men would be liable to term them providential in a pre-scientific age. And this was said without the smallest notion apparently in the writer's mind that he was giving utterance to any thing that could startle or alarm—it was said as a kind of commonplace. It would seem that in his view there was a time when mankind, lost in ignorance, might, without forfeiting entirely their title to the name of rational creatures, believe in a Providence, but that since that period another and greater power has arisen under the name of science, and this power has gone to war with Providence, and Providence is driven from the field—and we have now the happiness of living in the scientific age, when Providence is no longer to be treated as otherwise than an idle dream."[2]

Of the mental attitude, very general beyond the limits of the scientific world, which these utterances of Mr. Gladstone exemplify, he has since given further illustration; and, in his anxiety to check a movement he thinks mischievous, has so conspicuously made himself the exponent of the anti-scientific view, that we may fitly regard his thoughts on the matter as typical. In an address delivered by him at the Liverpool College, and since republished with additions, he says:

"Upon the ground of what is termed evolution, God is relieved of the labor of creation; in the name of unchangeable laws, He is discharged from governing the world."

This passage proves the kinship between Mr. Gladstone's conception of things and that entertained by the Greeks to be even closer than

[1] "History of Greece," vol. i., p. 466.

[2] *Morning Post*, May 15, 1872.

above alleged; for its implication is, not simply that the scientific interpretation of vital and social phenomena as conforming to fixed laws is repugnant to him, but that the like interpretation of inorganic phenomena is repugnant. In common with the ancient Greek, he regards as irreligious any explanation of Nature which dispenses with immediate divine superintendence. He appears to overlook the fact that the doctrine of gravitation, with the entire science of physical astronomy, is open to the same charge as this which he makes against the doctrine of evolution; and he seems not to have remembered that throughout the past each further step made by Science has been denounced for reasons like those which he assigns.[1]

It is instructive to observe, however, that, in these prevailing conceptions expressed by Mr. Gladstone, which we have here to note as excluding the conception of a Social Science, there is to be traced a healthful process of compromise between old and new. For, as, in the current conceptions about the order of events in the lives of persons, there is a partnership, wholly illogical though temporarily convenient, between the ideas of natural causation and of providential interference, so, in the current political conceptions, the belief in divine interpositions goes along with, and by no means excludes, the belief in a natural production of effects on society by natural agencies set to work. In relation to the occurrences of individual life, we displayed our national aptitude for thus entertaining mutually-destructive ideas, when an unpopular prince suddenly gained popularity by outliving certain abnormal changes in his blood, and when, on the occasion of his recovery, providential aid and natural causation were unitedly recognized by a thanksgiving to God and a baronetcy to the doctor. And, similarly, we see that, throughout all our public actions, the theory which Mr. Gladstone represents, that great men are providentially raised up to do things God has decided upon, and that the course of affairs is supernaturally ordered thus or thus, does not in the least interfere with the passings of measures calculated to achieve desired ends in ways classed as natural, and nowise modifies the discussion of such measures on their merits, as estimated in terms of cause and consequence. While the prayers with which each legislative sit-

[1] In the appendix to his republished address, Mr. Gladstone, in illustration of the views he condemns, refers to that part of "First Principles" which, treating of the reconciliation of Science and Religion, contends that this consists in a united recognition of an Ultimate Cause which, though ever present to consciousness, transcends knowledge. Commenting on this view, he says: "Still it vividly recalls to mind an old story of the man who, wishing to be rid of one who was in his house, said: 'Sir, there are two sides to my house, and we will divide them; you shall take the outside.'" This seems to me by no means a happily-chosen simile, since it admits of an interpretation exactly opposite to the one Mr. Gladstone intends. The doctrine he combats is that Science, unable to go beyond the outsides of things, is forever debarred from reaching, and even from conceiving, the power within them; and, this being so, the relative positions of Religion and Science may be well represented by inverting the application of his figure.

ting commences show a nominal belief in an immediate divine guidance, the votes with which the sitting ends, given in pursuance of reasons which the speeches assign, show us a real belief that the effects will be determined by the agencies set to work.

Still it is clear that the old conception, while it qualifies the new but little in the regulating of actions, qualifies it very much in the formation of theories. There can be no complete acceptance of Sociology as a science so long as the belief in a social order not conforming to natural law survives. Hence, as already said, considerations touching the study of Sociology, not very influential even over the few who recognize a Social Science, can have scarcely any effects on the great mass to whom a Social Science is an incredibility.

I do not mean that this prevailing imperviousness to scientific conceptions of social phenomena is to be regretted. As implied in a foregoing paragraph, it is part of the required adjustment between existing opinions and the forms of social life at present requisite. With a given phase of human character there must, to maintain equilibrium, go an adapted class of institutions, and a set of thoughts and sentiments in tolerable harmony with those institutions. Hence, it is not to be wished that, with the average human nature we now have, there should be a wide acceptance of views natural only to a more highly-developed social state, and to the improved type of citizen accompanying such a state. The desirable thing is, that a growth of ideas and feelings tending to produce modification shall be joined with a continuance of ideas and feelings tending to preserve stability. And it is one of our satisfactory social traits, exhibited in a degree never before paralleled, that along with a mental progress which brings about considerable changes, there is a devotion of thought and energy to the maintenance of existing arrangements, and creeds, and sentiments—an energy sufficient even to reinvigorate some of the old forms and beliefs that were decaying. When, therefore, a distinguished statesman, anxious for human welfare as he ever shows himself to be, and holding that the defense of established beliefs must not be left exclusively to its "standing army" of "priests and ministers of religion," undertakes to combat opinions at variance with a creed he thinks essential, the occurrence may be taken as adding another to the many signs of a healthful condition of society. That, in our day, one in Mr. Gladstone's position should think as he does, seems to me very desirable. That we should have for our working-king one in whom a purely-scientific conception of things had become dominant, and who was thus out of harmony with our present social state, would probably be detrimental, and might be disastrous.

For it cannot be too emphatically asserted that this policy of compromise, alike in institutions, in actions, and in beliefs, which especially characterizes English life, is a policy essential to a society going

through the transitions caused by continued growth and development. The illogicalities and the absurdities to be found so abundantly in current opinions and existing arrangements are those which inevitably arise in the course of perpetual readjustments to circumstances perpetually changing. Ideas and institutions proper to a past social state, but incongruous with the new social state that has grown out of it, surviving into this new social state they have made possible, and disappearing only as this new social state establishes its own ideas and institutions, are necessarily, during their survival, in conflict with these new ideas and institutions—necessarily furnish elements of contradiction in men's thoughts and deeds. And yet, as, for the carrying on of social life, the old must continue so long as the new is not ready, this perpetual compromise is an indispensable accompaniment of a normal development. Its essentialness we may see on remembering that it equally holds throughout the evolution of an individual organism. The structural and functional arrangements during growth are never quite right: always the old adjustment for a smaller size is made wrong by the larger size it has been instrumental in producing—always the transition-structure is a compromise between the requirements of past and future, fulfilling in an imperfect way the requirements of the present. And this, which is shown clearly enough where there is simple growth, is shown still more clearly where there are metamorphoses. A creature which leads at two periods of its existence two different kinds of life, and which, in adaptation to its second period, has to develop structures that were not fitted for its first, passes through a stage during which it possesses both partially—during which the old dwindles while the new grows: as happens, for instance, in creatures that continue to breathe water by external branchiæ during the time they are developing the lungs that enable them to breathe air. And thus it is with the changes produced by growth in societies, as well as with those metamorphoses accompanying change in the mode of life—especially those accompanying change from the predatory to the industrial life. Here, too, there must be transitional stages during which incongruous organizations coexist: the first remaining indispensable until the second has grown up to its work. Just as injurious as it would be to an amphibian to cut off its branchiæ before its lungs were well developed, so injurious must it be to a society to destroy its old institutions before the new have become well-organized enough to take their places.

Non-recognition of this truth characterizes too much the reformers, political, religious, and social, of our own time; as it has characterized those of past times. On the part of men eager to rectify wrongs and expel errors, there is still, as there ever has been, so absorbing a consciousness of the evils caused by old forms and old ideas, as to permit no consciousness of the benefits these old forms and old ideas have yielded. This partiality of view is, in a sense, necessary. There must

be division of labor here as elsewhere: some who have the function of attacking, and who, that they may attack effectually, must feel strongly the viciousness of that which they attack; some who have the function of defending, and who, that they may be good defenders, must over-value the things they defend. But while this one-sidedness has to be tolerated, as in great measure unavoidable, it is in some respects to be regretted. Though, with grievances less serious and animosities less intense than those which existed here in the past, and which exist still abroad, there go mitigated tendencies to a rash destructiveness on the one side, and an unreasoning bigotry on the other, yet even in our country and age there are dangers from the want of a due both-sidedness. In the speeches and writings of those who advocate various political and social changes, there is so continuous a presentation of injustices, and abuses, and mischiefs, and corruptions, as to leave the impression that, for securing a wholesome state of things, there needs nothing but to set aside present arrangements. The implication seems ever to be that all who occupy places of power, and form the regulative organization, are alone to blame for whatever is not as it should be, and that the classes regulated are blameless. "See the injuries which these institutions inflict on you," says the energetic reformer. "Consider how selfish must be the men who maintain them to their own advantage and your detriment," he adds; and then he leaves to be drawn the manifest inference that, were these selfish men got rid of, all would be well. Neither he nor his audience recognizes the facts that regulative arrangements are essential; that the arrangements in question, along with their many vices, have some virtues; that such vices as they have do not result from an egoism peculiar to those who uphold and work them, but result from a general egoism—an egoism no less decided in those who complain than in those complained of. Inequitable government can be upheld only by the aid of a people correspondingly inequitable, in its sentiments and acts. Injustice cannot reign, if the community does not furnish a due supply of unjust agents. No tyrant can tyrannize over a people save on condition that the people is bad enough to supply him with soldiers who will fight for his tyranny and keep their brethren in slavery. Class-supremacy cannot be maintained by the corrupt buying of votes, unless there are multitudes of voters venal enough to sell their votes. It is thus everywhere and in all degrees—misconduct among those in power is the correlative of misconduct among those over whom they exercise power.

And, while, in the men who urge on changes, there is an unconsciousness that the evils they denounce are rooted in the nature common to themselves and other men, there is also an unconsciousness that amid the things they would throw away there is much worth preserving. This holds of beliefs more especially. Along with the destructive tendency there goes but little constructive tendency. The

criticisms made, imply that it is requisite only to dissipate errors, and that it is needless to insist on truths. It is forgotten that, along with forms which are bad, there is a large amount of substance which is good. And those to whom there are addressed condemnations of the forms, unaccompanied by the caution that there is a substance to be preserved in higher forms, are left, not only without any coherent system of guiding beliefs, but without any consciousness that one is requisite.

Hence the need, above admitted, for an active defense of that which exists, carried on by men convinced of its entire worth; so that those who attack may not destroy the good along with the bad.

And here let me point out, specifically, the truth already implied, that studying Sociology scientifically leads to fairer appreciations of different parties, political, religious, and other. The conception initiated and developed by Social Science is at the same time radical and conservative—radical to a degree beyond any thing which current radicalism conceives; conservative to a degree beyond any thing conceived by present conservatism. When there has been adequately seized the truth that societies are products of evolution, assuming, in their various times and places, their various modifications of structure and function, there follows the conviction that what, relatively to our thoughts and sentiments, were arrangements of extreme badness, had fitnesses to conditions which made better arrangements impracticable: whence comes a tolerant interpretation of past tyrannies at which even the bitterest Tory of our own days would be indignant. On the other hand, after observing how the processes that have brought things to their present stage are still going on, not with a decreasing rapidity indicating approach to cessation, but with an increasing rapidity that implies long continuance and immense transformations, there follows the conviction that the remote future has in store forms of social life higher than any we have imagined: there comes a faith transcending that of the radical, whose aim is some reorganization admitting of comparison to organizations which exist. And while this conception of societies as naturally evolved, beginning with small and simple types which have their short existences and disappear, advancing to higher types that are larger, more complex, and longer-lived, coming to still higher types like our own, great in size, complexity, and duration, and promising types transcending these in times after existing societies have died away—while this conception of societies implies that in the slow course of things changes almost immeasurable in amount are possible, it also implies that but small amounts of such changes are possible within short periods.

Thus, the theory of progress disclosed by the study of Sociology as science is one which greatly moderates the hopes and the fears of extreme parties. After clearly seeing that the structures and actions throughout a society are determined by the properties of its

units, and that (external disturbances apart) the society cannot be substantially and permanently changed, it becomes easy to see that great alterations cannot suddenly be made to much purpose. And when both the party of progress and the party of resistance perceive that the institutions which at any time exist are more deeply rooted than they supposed—when the one party perceives that these institutions, imperfect as they are, have a temporary fitness, while the other party perceives that the maintenance of them, in so far as it is desirable, is in great measure guaranteed by the human nature they have grown out of—there must come a diminishing violence of attack on one side, and a diminishing perversity of defense on the other. Evidently, so far as a doctrine can influence general conduct (which it can do, however, in but a comparatively small degree), the doctrine of evolution, in its social applications, is calculated to produce a *steadying* effect, alike on thought and action.

If, as seems likely, some should propose to draw the seemingly awkward corollary that, it matters not what we believe or what we teach, since the process of social evolution will take its own course in spite of us, I reply that, while this corollary is in one sense true, it is in another sense untrue. Doubtless, from all that has been said, it follows that, supposing surrounding conditions continue the same, the evolution of a society cannot be in any essential way diverted from its general course; though it also follows (and here the corollary is at fault) that the thoughts and actions of individuals, being natural factors that arise in the course of the evolution itself, and aid in further advancing it, cannot be dispensed with, but must be severally valued as increments of the aggregate force producing change. But, while the corollary is even here partially misleading, it is, in another direction, far more seriously misleading. For, though the process of social evolution is, in its general character, so far predetermined that its successive stages cannot be antedated, and that hence no teaching or policy can advance it beyond a certain normal rate, which is limited by the rate of organic modification in human beings, yet it is quite possible to perturb, to retard, or to disorder the process. The analogy of individual development again serves us. The unfolding of an organism, after its special type, has its approximately uniform course, taking its tolerably definite time; and no treatment that may be devised will fundamentally change or greatly accelerate these: the best that can be done is to maintain the required favorable conditions. But it is quite easy to adopt a treatment which shall dwarf, or deform, or otherwise injure: the processes of growth and development may be, and very often are, hindered or deranged, though they cannot be artificially bettered. Similarly with the social organism. Though by maintaining favorable conditions there cannot be more good done than that of letting social progress go on unhindered, yet an immensity of mischief may be done in the way of disturbing and distorting and re-

pressing, by policies carried out in pursuance of erroneous conceptions. And thus, notwithstanding first appearances to the contrary, there is a very important part to be played by a true theory of social phenomena.

A few words to those who think these general conclusions discouraging, may be added. Probably the more enthusiastic, hopeful of great ameliorations in the state of mankind, to be brought about rapidly by propagating this belief or initiating that reform, will feel that a doctrine negativing their sanguine anticipations takes away much of the stimulus to exertion. If large advances in human welfare can come only in the slow process of things, which will inevitably bring them, why should we trouble ourselves?

Doubtless it is true that, on visionary hopes, rational criticisms have a depressing influence. It is better to recognize the truth, however. As, between infancy and maturity, there is no short cut by which there may be avoided the tedious process of growth and development through insensible increments, so there is no way from the lower forms of social life to the higher, but one passing through small successive modifications. If we contemplate the order of Nature, we see that everywhere vast results are brought about by accumulations of minute actions. The surface of the earth has been sculptured by forces which in the course of a year produce alterations scarcely anywhere visible. Its multitudes of different organic forms have arisen by processes so slow, that, during the periods our observations extend over, the results are in most cases inappreciable. We must be content to recognize these truths and conform our hopes to them. Light falling upon a crystal is capable of altering its molecular arrangements, but it can do this only by a repetition of impulses almost innumerable: before a unit of ponderable matter can have its rhythmical movements so increased by successive ethereal waves as to be detached from its combination and in another way arranged, millions of such ethereal waves must successively make infinitesimal additions to its motion. Similarly, before there arise, in human nature and human institutions, changes having that permanence which makes them an acquired inheritance for the human race, there must go innumerable recurrences of the thoughts, and feelings, and actions, conducive to such changes. The process cannot be abridged, and must be gone through with due patience.

Thus, admitting that for the fanatic some wild anticipation is needful as a stimulus, and recognizing the usefulness of his delusion as adapted to his particular nature and his particular function, yet the man of higher type must be content with greatly-moderated expectations, while he perseveres with undiminished efforts. He has to see how comparatively little can be done, and yet to find it worth while to do that little: so uniting philanthropic energy with philosophic calm.

# FURS AND THEIR WEARERS.

By JAMES H. PARTRIDGE.

THE skins used for fancy furs and robes are mostly obtained from the carnivorous or flesh-eating animals; as the sable, marten, mink, ermine, seal, otter, bear, etc.: some are obtained from the rodents or gnawers; as the beaver, coypou, or nutria, muskrat, rabbit, etc.: and a few are obtained from the ruminants, or those that chew the cud; as the bison, that supplies our buffalo-robes; and the paseng or wild-goat of Persia and the Caucasus, and the Assyrian or Siberian sheep, from whose young kids and lambs we obtain the much-used Astrakhan. We give illustrations of the principal fur-bearing animals, several of which are taken from Tenney's excellent "Manual of Zoology."

FIG. 1.

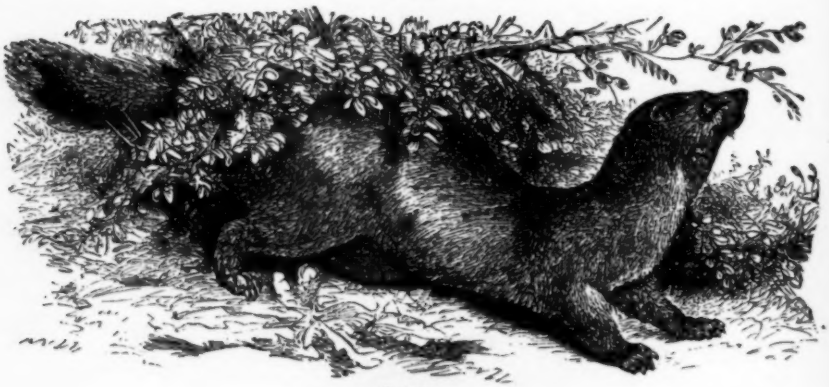
AMERICAN BUFFALO. (Tenney.)

As furs are generally worn by those who consult taste rather than necessity, their use depends very much upon fashion and caprice. Hence their price varies much at different times, and is not always regulated by their intrinsic value. As it is natural to prefer articles that are rare and far-fetched, and as furs can be easily carried to any part of the world, most prefer foreign to domestic furs of the same quality. Thus we export much of our fox, marten, fisher, otter, beaver, and muskrat fur, while we import Astrakhan, Russian sable, ermine, Siberian squirrel, French rabbit, or cony, chinchilla, and nutria fur.

At the present time, much of the fur worn is colored. In some cases, the hair, fur, and skin, are all colored; as the Astrakhan: but in most cases the end of the hair or fur only is tinted, while the skin re-

mains untouched. The object of the tinting appears to be, to make all parts of the fur on a skin of the same color; to make an inferior fur appear like a superior one of the same kind; or to make the fur of one animal pass for that of another; as, for instance, the marten for the sable. Dyed furs are generally not durable—soon fade, and ap-

Fig. 2.



Sable.

pear as if old and worn. Hair and fur frequently grow together on fur-bearing animals; and, if the fur alone be wanted, the hair, which is usually longer than the fur, must be plucked or otherwise removed. During the spring and summer the fur of many land animals fades, and is shed for the season; leaving nothing but hair remaining, or perhaps

Fig. 3.

Pine Marten.

fur inferior in color and fineness. In the autumn, a new coat of the animal's finest fur is grown, which has comparative freshness and brilliancy of color. Furs, taken in the best season in the higher latitudes,

are called prime; those taken out of season are, in common parlance, said to be *stagy*.

Other things being the same, the colder the climate the better the fur. Hence our best furs are generally obtained in the higher latitudes, or in cool mountain-regions, during the prevalence of snow and the severity of winter. Thus the hunter is exposed to much labor, fatigue, privation, and danger. They who, in the inhospitable clime of Siberia, hunt the sable, in the most inclement season of the year, undergo intense suffering and hardship.

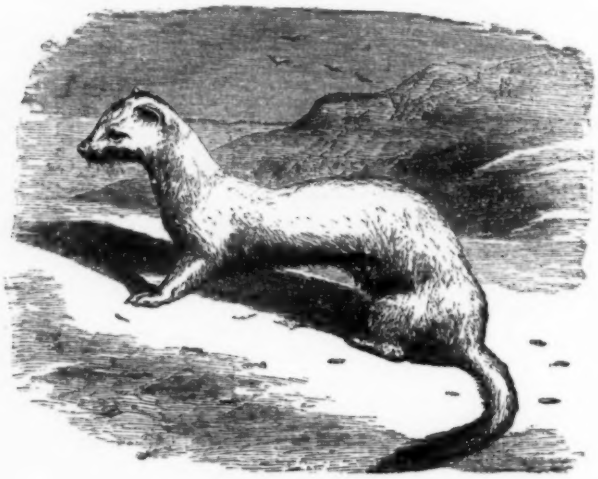
FIG. 4.

MINK.

Sables are three or four times as large as the common weasel, to which family they belong. They are usually taken between November and February, in snares, traps, or pitfalls, baited with flesh or fish. They are then of a beautiful black color, but are brownish in summer. The fur of the Russian sable, by its richness and elegance, maintains its preëminence. It may be distinguished from all other furs, by the hairs turning and lying with equal ease in either direction; which may be shown by blowing it. It is limited in quantity, only about 15,000 being caught yearly, and the price of the best is almost fabulous: a furrier suggests from $20 to $150 per skin. Fresh furs have what dealers call a bloomy appearance. Dyed sables generally lose their gloss, whether the lower hair has taken the dye or not; and the hairs are twisted or crisped. Some smoke the skins to blacken them, but the smell and crisped hairs betray the cheat. To detect dyeing or smoking, rub the fur with a moist linen cloth, which will then be blackened. The Chinese, however, dye the sables so that the color lasts, and the fur keeps its gloss; then, the fraud can be detected only by the crisped hairs.

The fur of the pine marten is nearly equal to that of the sable. Its color is a lustrous brown, and it is frequently tinted so as to resemble the real sable; and efforts are said to have been sometimes made to palm it upon buyers as the genuine Russian. That which is obtained in America, some 200,000 skins annually, which is somewhat better than the European, is usually called, by dealers, Hudson Bay sable. It is an excellent and valuable fur, very full and soft, and, like the Russian sable, is much used for muffs, capes, collars, boas, and other kinds of fancy furs. The fur of the beech or stone marten is much inferior to that of the sable or pine marten. It is of a yellowish brown, and, though often colored to represent pine marten or sable, the practised eye can easily distinguish it from them. The best specimens of the fur are obtained in Europe, where it is much used; but in this country, at the present time, it is not used at all. The skins of the fisher or pennant's marten, whose fur is quite valuable, are also exported. Less than 10,000 are caught yearly.

FIG. 5.



ERMINE, OR STOAT.

The mink is constantly found in almost every part of North America, some 250,000 being taken annually; yet, contrary to the general rule, it has been a very fashionable fur here for several years, for muffs, collars, etc. The color of the finest is chestnut-brown, glossed with black. The lighter colored is of less value, but it is often dyed so as to deceive the ignorant or unobserving. Dealers sometimes call it American sable. We occasionally hear of attempts to tame the mink, and raise it on a large scale in a minkery or suitable place of confinement. The present high price of the fur presents a strong inducement, but I do not know that there is any prospect of success.

The ermine is abundant in the northern parts of Asia, Europe, and America, about 400,000 being taken yearly. It is much smaller than the sable. In summer it is of a yellowish brown, and is then called a stoat; and its fur is known among furriers by the name of *roselet.* In winter, at the north, it becomes a pure white, and extremely beautiful. Farther south, the change from brown to white is less perfect. The end of the tail remains black during the year. It was formerly very valuable, and was much used in England to line the official robes of judges and magistrates. It is still considered a choice fur. The color of the Canada lynx is light gray, waved with black. Its fur is long, fine, and very thick, and furnishes a most beautiful material for robes, ladies' sets, trimmings, etc. Some 50,000 skins are sent to market each year. The Siberian squirrel is a neat, lively, active little animal. Its fur in winter is short and silky, and of a pretty gray color. The skins are used quite extensively for making ladies' sets and children's furs; several millions being taken annually.

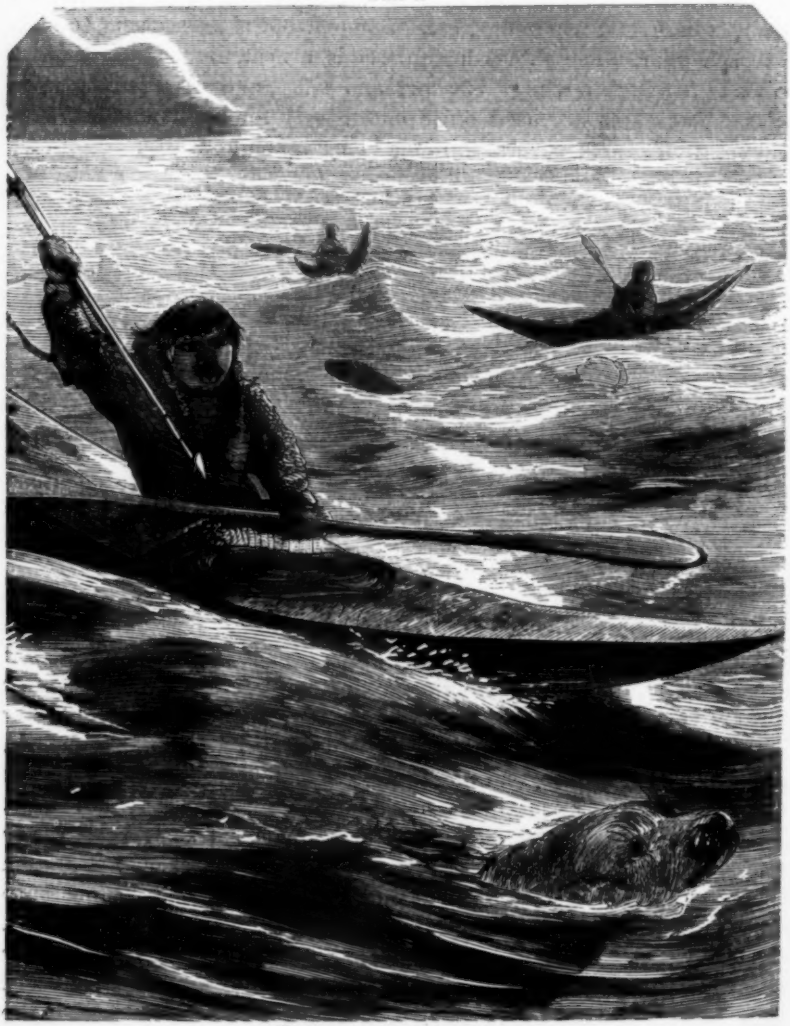
FIG. 6.

CANADA LYNX. (Tenney.)

The seal is a quadruped which spends the larger portion of its time in the water, and whose shape very much resembles that of a fish. Its neck is short, its body is tapering from the shoulders, and its legs or flippers very much resemble fins. It can stay a long time under water without breathing, at which time it can close its nostrils and ears. The species are numerous, differ greatly in size, and are found in almost every part of the world, but abound mostly in the higher latitudes. They live upon fish and other aquatic animals, eat their food in the water, but in fine weather they prefer the ice, or the rocks and sand on shore, on which to sleep, to bask in the sun, or to play. The harp seal furnishes the Esquimaux and Greenlanders with food, clothing, light, covering for their boats, and other articles of convenience. The eyes of seals are dark and lustrous, their sense of hearing acute, and they delight in musical sounds. Their heads so much resemble the human form, and their movements are so graceful, that the ancient

poets found no difficulty in transforming them, in imagination, into tritons, sirens, nereids, etc., and making them the companions of Neptune. The tales of mermaids and mermen, by modern sailors, are usually caused by them, though the manatus may sometimes be the cause of the illusion. Several species have a fine, close fur. Others, like the common seal, have only coarse hair. The skins of these, when dressed with the hair on, are used to cover trunks, to make gloves, soldiers' caps, etc. The skins of the sea-bear, or fur-seal, are extensively used for gentlemen's and ladies' sets, and for various other purposes. The

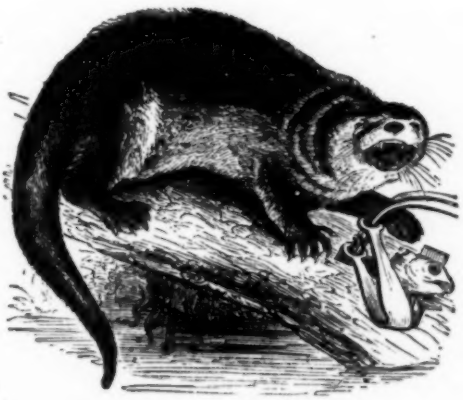
FIG. 7.



ESQUIMAUX SPEARING SEALS.

original color of the fur varies from black, through brownish red to ash-colored; and the dyer gives it whatever tint the market requires. The skins have long hairs, black, brown, or gray, which are taken out before the fur is in a condition to use. The number of seals of all kinds, now taken yearly, is not far from 1,000,000.

FIG. 8.



OTTER. (Tenney.)

A few years ago, a large number of skins, of what was then called in Britain the common fur-seal of commerce, was obtained from the islands of the Southern Ocean. Instead of taking a moderate number, and allowing the supply to be kept up, those engaged in the business made an indiscriminate slaughter of the animals, and in a few years

FIG. 9.

BEAVER. (Tenney.)

nearly exterminated them. In South Shetland, it was estimated that they killed 320,000; in the Island of Desolation, or Kerguelen, more than 1,000,000; and in South Georgia 1,200,000. The fur of this seal is

of a uniform brownish-white color above, and of a somewhat deep brown beneath. The fur-skin of this valuable animal is prepared in a peculiar manner. The long hair which conceals the fur is first removed, by heating the skin, and then carding it with a large wooden knife. The fur then appears in all its perfection, and was formerly much used in Europe for linings and borders of cloaks and mantles, for caps, etc.

FIG. 10.

INDIANS CATCHING MUSK-RATS.

But by far the most valuable fur that passes under the name of seal is that of the sea otter, or Alaska seal, which, while it has the habits of the seal, forms a connecting link between it and the otter. A large portion of this fur is obtained from two islands, St. Paul and St. George, in latitude about 56½° north, in the Sea of Behring or Kamtchatka, about 250 miles northwest of the peninsula of Alaska. These islands were sold by Russia to the United States as a part of

the Alaska territory. When, in 1869, General George H. Thomas was sent by our government to examine and report upon the country, he estimated the fur-bearing seals, or sea-otters, seen each summer on these islands, at from 5,000,000 to 15,000,000, lying in the rookeries, and covering hundreds of acres. For the last fifty or sixty years, the Russian Government had limited the number of skins to be taken yearly to some 80,000 or less. As General Thomas recommended that the hunting and killing of these animals should be regulated by law, Congress, in 1870, adopted substantially the Russian system; and in a few weeks the Alaska Company, of which Hon. Henry P. Haven,

FIG. 11.

CHINCHILLA.

of New London, Connecticut, is a prominent owner and influential officer, leased from the United States the islands of St. Paul and St. George. The company contracted to pay a rent of $55,000 per annum, and a revenue tax of $2.62½ on each fur-seal taken and shipped from the islands. Two United States officials are stationed on each of these islands to see that the company complies with the conditions of the lease, and to count the skins as they are shipped to San Francisco, where they are again counted by the custom-house officers. The number taken annually must not exceed 100,000. The catch in 1872 amounted to 96,069 skins. The sea-otter is the boldest swimmer of the amphibious tribe, for troops of them are met with 300 miles from land. When holding a fore-paw over their eyes, in order to look about them with more distinctness, they are called sea-apes. They are exclusively found in the North Pacific Ocean and on its borders, between the 49th and 60th degrees of latitude; and, although living mostly in the water, they are occasionally found on land very far from

the sea. Their fur is exceedingly fine, close, soft, and velvety, perfectly black in full season, but at other times of a shining, deep sepia, or of a rich chestnut-brown. The longer hairs are silky and glossy, but not very numerous, and are easily removed. The Chinese prize the fur of the sea-otter so highly that formerly they paid for the skins from sixty to seventy-five dollars each; but they value them somewhat less now. It still remains the choicest, most expensive, and most fashionable, fur of its kind in the market for gentlemen's sets, ladies' sacques, turbans, boas, muffs, etc., and consequently all inferior furs that resemble it are made to imitate it.

Otters are fierce, wild, and shy, nocturnal in their habits, live much in the water, and feed upon fish, which they catch with great dexterity. They love to sport by sliding down a bank of snow in winter,

FIG. 12.

ARCTIC FOX.

or clay in summer, especially when they can, at the bottom, plunge into water. The Canadian otter has long, glossy hair, of a dark color, and an inner fur, close, fine, and soft, of a deep, rich liver-brown. If the fur on any part of the skin lacks the right color, it is brought to the requisite tint by dyeing. The fur is much esteemed, and is used for caps, collars, gloves, etc., though much of it is exported to Europe. The number of otters taken yearly is supposed to be about 40,000.

Beavers have a broad, horizontally-flattened, and scaly tail, a webbed hind-foot, and a general form which is admirable for swimming. They live mostly in and near the water, in large companies,

and their chief food is bark and aquatic plants, which they collect in large heaps for the winter. Their powerful teeth enable them to gnaw down trees, even of the hardest wood. To obtain a proper depth of running water, with a surface varying little in height, they build a dam on a stream to make a pond, in which to build houses for winter, using trees and branches mixed with stones and mud. They cut their wood up-stream, and float it down. The houses are built where the

FIG. 13.

RACCOON. (Tenney.)

water is several feet deep, and their only entrance is at the bottom. They are continued so much above the water as to admit of an upper, dry apartment, approached from the lower, and usually occupied by two or three families. The fur of the American beaver is of a uniform reddish brown, fine, thick, and of the best quality. It was formerly almost wholly used for making hats. It is used for that now; also for gentlemen's caps, mufflers, and gloves. A large portion of it is exported to England.

FIG. 14.

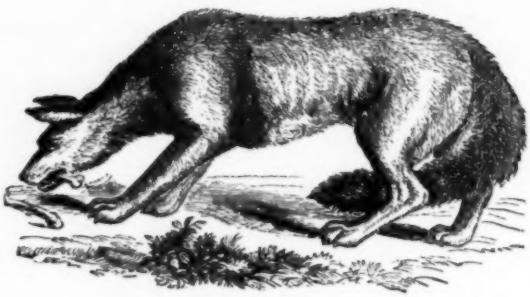
BADGER. (Tenney.)

Nutria fur is obtained from the coypou, or couia, a South American animal resembling the beaver in size and habits, but having a long, round tail. Its similarity, or that of its fur, to the otter and muskrat, may be inferred from its names: *nutria* meaning otter, and *myopotamus* river-mouse. In fact, Molina speaks of the coypou as a species of water-rat, of the size and color of the otter. In the workshops it is called the South American monkey. It has long, ruddy hair, and a

short, brownish, ash-colored fur, of considerable value, which has been largely exported to Europe for making hats. It has also been much used here for hats, gentlemen's sets, and other purposes. The fur somewhat resembles that of the beaver, as well as the otter. It is estimated that 3,000,000 are caught annually.

The muskrat, or musquash, is a native of North America, much smaller than the beaver, but with habits and appearance somewhat similar. Muskrats feed upon mussels, aquatic plants, and roots of grasses, and build winter-huts of sticks, grass, and mud, with an entrance under water, leading to a dry apartment above. In summer they dwell in extensive burrows along the banks of the rivers. The trapper, walking on the bank, hears the muskrat run from his hole into the water, observes where he stirs the mud, and puts the trap quietly down there. The number of skins taken yearly by trap and gun is immense; over 3,000,000. Many are manufactured into hats on both sides of the Atlantic, more than a million being exported annually to England for that purpose. Besides hats, they are used here largely for men's gloves, ladies' sets, robes, etc. They are frequently dyed to imitate mink, and are then called Alaska mink. They are also plucked and dyed to imitate seal and similar furs.

FIG. 15.



WOLF. (Tenney.)

The chinchilla is scarcely larger than a rat, and inhabits the cold mountain-regions of Chili and Peru. It is chiefly remarkable for its exquisitely fine fur, which is very soft, and of a pearly gray. It is used for ladies' and children's sets, but more especially for lining and trimming cloaks, pelisses, and other articles of clothing. Not more than 100,000 are taken yearly.

The fur of the northern hare, which is white in winter and brown in summer, is mostly used in the manufacture of hats. The skins of the common European rabbit or French cony are used for ladies' sets and children's furs. The fur is also used for hats. Several millions are taken each year.

The fur of the skunk is used, under the name of Alaska sable, for

ladies' sets, sacque-trimmings, etc., of an inferior quality. The black portions of the skin are sometimes carefully selected, completely deodorized, made into sets of furs of the natural color, and sold under the name of black marten. The pole-cat, or fitchet weasel, has long, coarse, dark-brown hair, and an under-coat of short, silky, pale-yellow fur. This fur, though inferior, is imported and used for ladies' sets, etc., and is sold under the name of fitch. The Virginia opossum has the habit of feigning itself dead if slightly struck or wounded, but, if seriously attacked and badly hurt, it will fight bravely. Its fur is a long, woolly down, which is of a dingy white. Though of little value, the fur is colored so as to resemble fitch, and is sold under that name.

The color of the arctic fox during winter is a pure white; in summer, brown, gray, or bluish. It is then called a cross or pied fox. The fur is long, fine, and woolly, and is occasionally used here for ladies' sets and other purposes, but it is mostly exported to Europe;

FIG. 16.

WOLVERINE. (Tenney.)

as are also the skins of the red fox and its varieties, the cross fox and the silver or black fox. The color of an adult silver fox when in prime fur is a deep, glossy black, with a silvery grizzle on the forehead and flanks. This variety is extremely rare, and its rich fur is more valuable than that of any other quadruped. The skin of the silvery fox of Labrador has been sold in London for $500.

The panda, or wah, of the Himalaya Mountains, is about the size of a large cat. It is covered with a soft, thickly-set fur, which, above, is of the richest cinnamon red; behind, of a fawn color; and, beneath, of a deep black—while its head is whitish, and its tail like a lady's boa, and banded with red and yellow. Fred. Cuvier calls this the most beautiful of known quadrupeds.

The color of the raccoon is light gray overlaid with black-tipped hairs. The outer hair is long and coarse, the inner softer and more like wool. The fur is mostly used for making hats. It is sometimes

used for robes, as linings for garments, etc. About 500,000 skins are taken yearly. The hair of the badger is fine, silky, and very long, especially behind. At the roots it is of a yellowish gray, black in the middle, and white at the tip. The skins were formerly made into pouches by the Highlanders. The dressed skins make the best pistol-furniture, and the hair is much used to make artists' brushes for spreading the colors and softening the shades in painting. Some 50,000 skins are sent to market annually.

The white or polar bear is an enormous animal, weighing sometimes 1,000 or 1,500 pounds; is wholly carnivorous, and feeds upon seals and other animals. The fur is long, fine, soft, woolly, and of a silvery-white color tinged with yellow. Its skin makes a magnificent robe. In the northern regions the skins of bears furnish the most useful and comfortable winter apparel. They are made into beds, coverlets, caps, gloves, and other articles of clothing. The black bear has hair comparatively soft and glossy. Its skin is used for hammer-cloths of carriages, pistol-holsters, rugs, caps, etc. The cinnamon bear of the Rocky Mountains has a more valuable fur than that of the black bear, of which it appears to be a variety.

There are various other animals that furnish robes of different quality and appearance, such as the wolverine, or glutton, the wild-cat, the coyote, or prairie-wolf, the different varieties of the white wolf, which is sometimes called the mountain or timber wolf. The growing scarcity of wild animals, and the resources of modern art, are gradually introducing into use various fabrics as artificial robes, many of them convenient and comfortable, and some of them even elegant and very desirable.

## CORRELATION OF VITAL WITH CHEMICAL AND PHYSICAL FORCES.[1]

By JOSEPH LE CONTE,

PROFESSOR OF GEOLOGY AND NATURAL HISTORY IN THE UNIVERSITY OF CALIFORNIA.

VITAL force; whence is it derived? What is its relation to the other forces of Nature? The answer of modern science to these questions is: It is derived from the lower forces of Nature; it is related to other forces much as these are related to each other—it is correlated with chemical and physical forces.

At one time matter was supposed to be destructible. By combustion or by evaporation matter seemed to be consumed—to pass out of existence; but now we know it only changes its form from the solid

[1] An abstract of two Lectures given to the class in Comparative Physiology in the University of California.

or liquid to the gaseous condition—from the visible to the invisible—and that amid all these changes the same quantity of matter remains. Creation or destruction of matter, increase or diminution of matter, lies beyond the domain of Science; her domain is confined entirely to the changes of matter. Now, it is the doctrine of modern science that the same is true of force. Force seems often to be annihilated. Two cannon-balls of equal size and velocity meet each other and fall motionless. The immense energy of these moving bodies seems to pass out of existence. But not so; it is changed into heat, and the exact amount of heat may be calculated; moreover, an equal amount of heat may be changed back again into an equal amount of momentum. Here, therefore, force is not lost, but is changed from a visible to an invisible form. Motion is changed from bodily motion into molecular motion. Thus heat, light, electricity, magnetism, chemical affinity, and mechanical force, are transmutable into each other, back and forth; but, amid all these changes, the amount of force remains unchanged. Force is incapable of destruction, except by the same power which created it. The domain of Science lies within the limits of these changes—creation and annihilation lie outside of her domain.

The mutual convertibility of forces into each other is called *correlation of forces;* the persistence of the same amount, amid all these protean forms, is called *conservation of force.*

The correlation of physical forces with each other and with chemical force is now universally acknowledged and somewhat clearly conceived. The correlation of vital force with these is not universally acknowledged, and, where acknowledged, is only imperfectly conceived. In 1859 I published a paper[1] in which I attempted to put the idea of correlation of vital force with chemical and physical forces in a more definite and scientific form. The views expressed in that paper have been generally adopted by physiologists. Since the publication of the paper referred to, the subject has lain in my mind, and grown at least somewhat. I propose, therefore, now to reëmbody my views in a more popular form, with such additions as have occurred to me since.

There are four planes of material existence, which may be represented as raised one above another. These are: 1. The plane of elementary existence; 2. The plane of chemical compounds, or mineral kingdom; 3. The plane of vegetable existence; and, 4. The plane of animal existence. Their relations to each other are truly expressed by writing them one above the other, thus:

4. *Animal Kingdom.*
3. *Vegetable Kingdom.*
2. *Mineral Kingdom.*
1. *Elements.*

[1] *American Journal of Science*, November, 1859. *Philadelphia Magazine*, vol. xix., p. 133.

Now, it is a remarkable fact that there is a special force, whose function it is to raise matter from each plane to the plane above, and to execute movements on the latter. Thus, it is the function of chemical affinity alone to raise matter from No. 1 to No. 2, as well as to execute all the movements, back and forth, by action and reaction; in a word, to produce all the phenomena on No. 2 which together constitute the science of chemistry. It is the prerogative of vegetable life-force alone to lift matter from No. 2 to No. 3, as well as to execute all the movements on that plane, which together constitute the science of vegetable physiology. It is the prerogative of animal life-force alone to lift matter from No. 3 to No. 4, and to preside over the movements on this plane, which together constitute the science of animal physiology. But there is no force in Nature capable of raising matter at once from No. 1 to No. 3, or from No. 2 to No. 4, without stopping and receiving an accession of force, of a different kind, on the intermediate plane. Plants cannot feed upon elements, but only on chemical compounds: animals cannot feed on minerals, but only on vegetables. We will see in the sequel that this is the necessary result of the principle of conservation of force in vital phenomena.

It is well known that atoms, in a nascent state, i. e., at the moment of their separation from previous combination, are endowed with peculiar and powerful affinity. Oxygen and nitrogen, nitrogen and hydrogen, hydrogen and carbon, which show no affinity for each other under ordinary circumstances, readily unite when one or both are in a nascent condition. The reason seems to be that, when the elements of a compound are torn asunder, the chemical affinity which previously bound them together is set free, ready and eager to unite the nascent elements with whatever they come in contact with. This state of exalted chemical energy is retained but a little while, because it is liable to be changed into some other form of force, probably heat, and is therefore no longer chemical energy. To illustrate by the planes: matter falling down from No. 2 to No. 1 generates force by which matter is lifted from No. 1 to No. 2. Decomposition generates the force by which combination is effected. This principle underlies every thing I shall further say.

There are, therefore, two ideas or principles underlying this paper: 1. The correlation of vital with physical and chemical forces; 2. That in all cases vital force is produced by decomposition—is transformed by nascent affinity. Neither of these is new. Grove, many years ago, brought out, in a vague manner, the idea that vital force was correlated with chemical and physical forces.[1] In 1848 Dr. Freke, M. R. I. A., of Dublin, first advanced the idea that vital force of animal life was generated by decomposition. In 1851 the same idea was brought out again by Dr. Walters, of St. Louis. These papers were un-

[1] In 1845 Dr. J. R. Mayer published a paper on "Organic Motion and Nutrition." I have not seen it.

known to me when I wrote my article. They have been sent to me in the last few years by their respective authors. Neither of these authors, however, extends this principle to vegetation, the most fundamental and most important phenomenon of life. In 1857 the same idea was again brought out by Prof. Henry, of the Smithsonian Institution, and by him extended to vegetation. I do not, therefore, now claim to have first advanced this idea, but I do claim to have in some measure rescued it from vagueness, and given it a clearer and more scientific form.

I wish now to apply these principles in the explanation of the most important phenomena of vegetable and animal life:

1. VEGETATION.—The most important phenomenon in the life-history of a plant—in fact, the starting-point of all life, both vegetable and animal—is the formation of organic matter in the leaves. The necessary conditions for this wonderful change of mineral into organic matter seem to be, sunlight, chlorophyl, and living protoplasm, or bioplasm. This is the phenomenon I wish now to discuss.

The plastic matters of which vegetable structure is built are of two kinds—amyloids and albuminoids. The amyloids, or starch and sugar groups, consist of C, H, and O; the albuminoids of C, H, O, N, and SP. The quantity of sulphur and phosphorus is very small, and we will neglect them in this discussion. The food out of which these substances are elaborated are, $CO_2$, $H_2O$, and $H_2N$—carbonic acid, water, and ammonia. Now, by the agency of sunlight in the presence of chlorophyl and bioplasm, these chemical compounds ($CO_2$, $H_2O$, $H_2N$) are torn asunder, or shaken asunder, or decomposed; the excess of O, or of O and H, is rejected, and the remaining elements in a nascent condition combine to form organic matter. To form the amyloids, starch, dextrine, sugar, cellulose, only $CO_2$ and $H_2O$ are decomposed, and excess of O rejected. To form albuminoids or protoplasm, $CO_2$, $H_2O$, and $H_2N$, are decomposed, and excess of O and H rejected.

It would seem in this case, therefore, that physical force (light) is changed into nascent chemical force, and this nascent chemical energy, under the peculiar conditions present, forms organic matter and reappears as vital force. Light falling on living green leaves is destroyed or consumed in doing the work of decomposition; disappears as light, to reappear as nascent chemical energy; and this in its turn disappears in forming organic matter, to reappear as the vital force of the organic matter thus formed. The light which disappears is proportioned to the O, or the O and H rejected; is proportioned also to the quantity of organic matter formed, and also to the amount of vital force resulting. To illustrate: In the case of amyloids, oxygen-excess falling or running down from plane No. 2 to plane No. 1 generates force to raise C, H, and O, from plane No. 2 to plane No. 3. In the case of albuminoids, oxygen-excess and hydrogen-excess running down from No. 2 to No. 1 generate force to raise C, H, O, and N, from No. 2 to

No. 3. To illustrate again: As sun-heat falling upon water disappears as heat, to reappear as mechanical power, raising the water into the clouds, so sunlight falling upon green leaves disappears as light, to reappear as vital force lifting matter from the mineral into the organic kingdom.

2. GERMINATION.—Growing plants, it is seen, take their life-force from the sun; but seeds germinate and commence to grow in the dark. Evidently there must be some other source from which they draw their supply of force. They cannot draw force from the sun. This fact is intimately connected with another fact, viz., that they do not draw their food from the mineral kingdom. The seed in germination feeds entirely upon a supply of organic matter laid up for it by the mother-plant. It is the decomposition of this organic matter which supplies the force of germination. Chemical compounds are comparatively stable—it requires sunlight to tear them asunder; but organic matter is more easily decomposed—it is almost spontaneously decomposed. It may be that heat (a necessary condition of germination) is the force which determines the decomposition. However this may be, it is certain that a portion of the organic matter laid up in the seed is decomposed, burned up, to form $CO_2$ and $H_2O$, and that this combustion furnishes the force by which the mason-work of tissue-making is accomplished. In other words, of the food laid up in the form of starch, dextrine, protoplasm, a portion is decomposed to furnish the force by which the remainder is organized. Hence the seed always loses weight in germination; it cannot develop unless it is in part consumed; "it is not quickened except it die." This self-consumption continues until the leaves and roots are formed; then it begins to draw force from the sun, and food from the mineral kingdom.

To illustrate: In germination, matter running down from plane No. 3 to plane No. 2 generates force by which other similar matter is moved about and raised to a somewhat higher position on plane No. 3. As water raised by the sun may be stored in reservoirs, and in running down from these may do work, so matter raised by sun-force into the organic kingdom by one generation is stored as force to do the work of germination of the next generation. Again, as, in water running through an hydraulic ram, a portion runs to waste, in order to generate force to lift the remainder to a higher level, so, of organic matter stored in the seed, a portion runs to waste to create force to organize the remainder.

Thus, then, it will be seen, that three things, viz., the absence of sunlight, the use of organic food, and the loss of weight, are indissolubly connected in germination, and all explained by the principle of conservation of force.

3. STARTING OF BUDS.—Deciduous trees are entirely destitute of leaves during the winter. The buds must start to grow in the spring without leaves, and therefore without drawing force from the sun.

Hence, also, food in the organic form must be, and is, laid up from the previous year in the body of the tree. A portion of this is consumed with the formation of $CO_2$ and $H_2O$, in order to create force for the development of the buds. So soon as by this means the leaves are formed, the plant begins to draw force from the sun, and food from the mineral kingdom.

4. Pale Plants.—Fungi and etiolated plants have no chlorophyl, therefore cannot draw their force from the sun, nor make organic matters from inorganic. Hence these also must feed on organic matter: not, indeed, on starch, dextrine, and protoplasm, but on decaying organic matter. In these plants the organic matter is taken up in some form intermediate between the planes No. 3 and No. 2. The matter thus taken up is, a portion of it, consumed with the formation of $CO_2$ and HO, in order to create force necessary to organize the remainder. To illustrate: Matter falling from some intermediate point between No. 2 and No. 3 to No. 2, produces force sufficient to raise matter from the same intermediate point to No. 3; a portion runs to waste downward, and creates force to push the remainder upward.

5. Growth of Green Plants at Night.—It is well known that almost all plants grow at night as well as in the day. It is also known that plants at night exhale $CO_2$. These two facts have not, however, as far as I know, been connected with one another, and with the principle of conservation of force. It is usually supposed that in the night the decomposition of $CO_2$ and exhalation of oxygen are checked by withdrawal of sunlight, and some of the $CO_2$ in the ascending sap is exhaled by a physical law. But this does not account for the growth. It is evident that, in the absence of sunlight, the force required for the work of tissue-building can be derived only from the decomposition and combustion of organic matter. There are two views as to the source of this organic matter, either or both of which may be correct: First. There seems to be no doubt that most plants, especially those grown in soils rich in *humus*, take up a portion of their food in the form of semi-organic matter, or soluble *humus*. The combustion of a portion of this in every part of the plant, by means of oxygen also absorbed by the roots, and the formation of $CO_2$, undoubtedly creates a supply of force night and day, independently of sunlight. The force thus produced by the combustion of a portion might be used to raise the remainder into starch, dextrine, etc., or might be used in tissue-building. During the day, the $CO_2$ thus produced would be again decomposed in the leaves by sunlight, and thus create an additional supply of force. During the night, the $CO_2$ would be exhaled.[1]

Again: It is possible that more organic matter is made by sunlight during the day than is used up in tissue-building. Some of this excess is again consumed, and forms $CO_2$ and $H_2O$, in order to con-

[1] For more full account, see my paper, *American Journal of Science*, November, 1859, sixth and seventh heads.

tinue the tissue-building process during the night. Thus the plant during the day stores up sun-force sufficient to do its work during the night. It has been suggested by Dr. J. C. Draper,[1] though not proved, or even rendered probable, that the force of tissue-building (*force plastique*) is always derived from decomposition, or combustion of organic matter. In that case, the force of organic-matter formation is derived from the sun, while the force of tissue-building (which is relatively small) is derived from the combustion of organic matter thus previously formed.

6. FERMENTATION.—The plastic matters out of which vegetable tissue is built, and which are formed by sunlight in the leaves, are of two kinds, viz., amyloids (dextrine, sugar, starch, cellulose), and albuminoids, or protoplasm. Now, the amyloids are comparatively stable, and do not spontaneously decompose; but the albuminoids not only decompose spontaneously themselves, but drag down the amyloids with which they are associated into concurrent decomposition—not only change themselves, but propagate a change into amyloids. Albuminoids, in various stages and kinds of decomposition, are called ferments. The propagated change in amyloids is called fermentation. By various kinds of ferments, amyloids are thus dragged down step by step to the mineral kingdom, viz., to $CO_2$ and $H_2O$. The accompanying table exhibits the various stages of the descent of starch, and the ferments by which they are effected:[2]

| | |
|---|---|
| 1. Starch ..... | Diastase. |
| 2. Dextrine ..... | |
| 3. Sugar ..... | |
| 4. Alcohol and $CO_2$ ..... | Yeast. |
| 5. Acetic acid ..... | Mother of vinegar. |
| 6. $CO_2$ and HO ..... | Mould. |

By appropriate means, the process of descent may be stopped on any one of these planes. By far too much is, unfortunately, stopped on the fourth plane. The manufacturer and chemist may determine the downward change through all the planes, and the chemist has recently succeeded in ascending again to No. 4; but the plant ascends and descends the scale at pleasure (avoiding, however, the fourth and fifth), and even passes at one step from the lowest to the highest.

Now, it will be seen by the table that, connected with each of these descensive changes, there is a peculiar ferment associated. Diastase determines the change from starch to dextrine and sugar—saccharification; yeast, the change from sugar to alcohol—fermentation; mother of vinegar, the change from alcohol to acetic acid—acetification; and a peculiar mould, the change from acetic acid to $CO_2$ and water. But

[1] *American Journal of Science*, November, 1872. The experiments of Dr. Draper are inconclusive, because they are made on *seedlings*, which, until their supply of organic food is exhausted, are independent of sunlight.

[2] J. C. Draper, *American Journal of Science*, November, 1872

what is far more wonderful and significant is, that, associated with each of these ferments, except diastase, and therefore with each of these descensive changes, except the change from starch to sugar, or saccharification, there is a peculiar form of life. Associated with alcoholic fermentation, there is the yeast-plant; with acetification, the vinegar-plant; and, with the decomposition of vinegar, a peculiar kind of mould. We will take the one which is best understood, viz., yeast-plant (saccharomyce), and its relation to alcoholic fermentation.

It is well known that, in connection with alcoholic fermentation, there is a peculiar unicelled plant which grows and multiplies. Fermentation never takes place without the presence of this plant; this plant never grows without producing fermentation, and the rapidity of the fermentation is in exact proportion to the rapidity of the growth of the plant. But, as far as I know, the fact has not been distinctly brought out that the decomposition of the sugar into alcohol and carbonic acid furnishes the force by which the plant grows and multiplies. If the growing cells of the yeast-plant be observed under the microscope, it will be seen that the carbonic-acid bubbles form, and therefore probably the decomposition of sugar takes place only in contact with the surface of the yeast-cells. The yeast-plant not only assimilates matter, but also force. It decomposes the sugar, in order that it may assimilate the chemical force set free.

We have already said that the change from starch to sugar, determined by diastase (saccharification), is the only one in connection with which there is no life. Now, it is a most significant fact, in this connection, that this is also the only change which is not, in a proper sense, descensive, or, at least, where there is no decomposition.

We now pass from the phenomena of vegetable to the phenomena of animal life.

7. Development of the Egg in Incubation.—The development of the egg in incubation is very similar to the germination of a seed. An egg consists of albuminous and fatty matters, so inclosed that, while oxygen of the air is admitted, nutrient matters are excluded. During incubation the egg changes into an embryo; it passes from an almost unorganized to a highly-organized condition, from a lower to a higher condition. There is work done: there must be expenditure of force; but, as we have already seen, vital force is always derived from decomposition. But, as the matters to be decomposed are not taken *ab extra*, the egg must consume itself; that it does so, is proved by the fact that in incubation the egg absorbs oxygen, eliminates $CO_2$ and probably $H_2O$, and loses weight. As in the seed, a portion of the matters contained in the egg is consumed in order to create force to organize the remainder. Matter runs down from plane No. 4 to plane No. 2, and generates force to do the work of organization on plane No. 4. The amount of $CO_2$ and $H_2O$ formed, and therefore the loss of weight, is a measure of the amount of plastic work done.

8. Development within the Chrysalis Shell.—It is well known that many insects emerge from the egg not in their final form, but in a wormlike form, called a larva. After this they pass into a second passive state, in which they are again covered with a kind of shell—a sort of second egg-state, called the chrysalis. From this they again emerge as the perfect insect. The butterfly is the most familiar, as well as the best illustrated, of these changes. The larva or caterpillar eats with enormous voracity, and grows very rapidly. When its growth is complete, it covers itself with a shell, and remains perfectly passive and almost immovable for many days or weeks. During this period of quiescence of animal functions there are, however, the most important changes going on within. The wings and legs are formed, the muscles are aggregated in bundles for moving these appendages, the nervous system is more highly developed, the mouth, organs, and alimentary canal, are greatly changed and more highly organized, the simple eyes are changed into compound eyes. Now, all this requires expenditure of force, and therefore decomposition of matter; but no food is taken, therefore the chrysalis must consume its own substance, and therefore lose weight. It does so; the weight of the emerging butterfly is in many cases not one-tenth that of the caterpillar. Force is stored up in the form of organic matter only to be consumed in doing plastic work.

9. Mature Animals.—Whence do animals derive their vital force? I answer, from the decomposition of their food and the decomposition of their tissues.

Plants, as we have seen, derive their vital force from the decomposition of their mineral food. But the chemical compounds on which plants feed are very stable. Their decomposition requires a peculiar and complex contrivance for the reception and utilization of sunlight. These conditions are wanting in animals. Animals, therefore, cannot feed on chemical compounds of the mineral kingdom; they must have organic food, which easily runs into decomposition; they must feed on the vegetable kingdom.

Animals are distinguished from vegetables by incessant decay in every tissue—a decay which is proportional to animal activity. This incessant decay necessitates incessant repair, so that the animal body has been likened to a temple on which two opposite forces are at work in every part, the one tearing down, the other repairing the breach as fast as made. In vegetables no such incessant decay has ever been made out. If it exists, it must be very trifling in comparison. Protoplasm, it is true, is taken up from the older parts of vegetables, and these parts die; but the protoplasm does not seem to decompose, but is used again for tissue-building. Thus the internal activity of animals is of two kinds, tissue-destroying and tissue-building; while that of plants seems to be, principally, at least, of one kind, tissue-building. Animals use food for force and repair and growth, and in the mature

animal only for force and repair. Plants use food for force and growth —they never stop growing.

Now, the food of animals is of two kinds, amyloids and albuminoids. The carnivora feed entirely on albuminoids; the herbivora on both amyloids and albuminoids. All this food comes from the vegetable kingdom directly in the case of herbivora, indirectly in the case of carnivora. Animals cannot make organic matter. Now, the tissues of animals are wholly albuminoid. It is obvious, therefore, that for the repair of the tissues the food must be albuminoid. The amyloid food, therefore (and, as we shall see in carnivora, much of the albuminoid), must be used wholly for force. As coal or wood, burned in a steam-engine, changes chemical into mechanical energy, so food, in excess of what is used for repair, is burned up to produce animal activity. Let us trace more accurately the origin of animal force by examples.

10. CARNIVORA.—The food of carnivora is entirely albuminoid. The idea of the older physiologists, in regard to the use of this food, seems to have been as follows: Albuminoid matter is exceedingly unstable; it is matter raised, with much difficulty and against chemical forces, high, and delicately balanced on a pinnacle, in a state of unstable equilibrium, for a brief time, and then rushes down again into the mineral kingdom. The animal tissues, being formed of albuminoid matter, are short-lived; the parts are constantly dying and decomposing; the law of death necessitates the law of reproduction; decomposition necessitates repair, and therefore food for repair. But the force by which repair is effected was for them, and for many physiologists now, underived, innate. But, the doctrine maintained by me in the paper referred to is, that the decomposition of the tissues creates not only the necessity, but also the force, of repair.

Suppose, in the first place, a carnivorous animal uses just enough food to repair the tissues, and no more—say an ounce. Then I say the ounce of tissue decayed not only necessitates the ounce of albuminous food for repair, but the decomposition sets free the force by which the repair is effected. But it will be perhaps objected that the force would all be consumed in repair, and none left for animal activity of all kinds. I answer: it would not all be used up in repair, for, the food being already albuminoid, there is probably little expenditure of force necessary to change it into tissue; while, on the other hand, the force generated by the decomposition of tissue into $CO_2$, $H_2O$, and urea, is very great—the ascensive change is small, the descensive change is great. The decomposition of one ounce of albuminous tissue into $CO_2$, $H_2O$, and urea, would therefore create force sufficient not only to change one ounce of albuminous matter into tissue, but also leave a considerable amount for animal activities of all kinds. A certain quantity of matter, running down from plane No. 4 to plane No. 2, creates force enough not only to move the same quantity of matter about on plane No. 2, but

also to do much other work besides. It is probable, however, that the wants of animal activity are so immediate and urgent that, under these conditions, much food would be burned for this purpose, and would not reach the tissues, and the tissues would be imperfectly repaired, and would therefore waste.

Take next the carnivorous animal full fed. In this case there can be no doubt that, while a portion of the food goes to repair the tissues, by far the larger portion is consumed in the blood, and passes away partly as $CO_2$ and $H_2O$ through the lungs, and partly as urea through the kidneys. This part is used, and can be of use only, to create force. The food of carnivora, therefore, goes partly to tissue-building, and partly to create heat and force. The force of carnivorous animals is derived partly from decomposing tissues and partly from food-excess consumed in the blood.

11. Herbivora.—The food of herbivora and of man is mixed—partly albuminoid and partly amyloid. In man, doubtless, the albuminoids are usually in excess of what is required for tissue-building; but in herbivora, probably, the albuminoids are not in excess of the requirements of the decomposing tissues. In this case, therefore, the whole of the albuminoids is used for tissue-making, and the whole of the amyloids for force-making. In this class, therefore, these two classes of food may be called tissue-food and force-food. The force of these animals, therefore, is derived partly from the decomposition of the tissues, but principally from the decomposition and combustion of the amyloids and fats.

Some physiologists speak of the amyloid and fat food as being burned to keep up the animal heat; but it is evident that the prime object in the body, as in the steam-engine, is not heat, but force. Heat is a mere condition and perhaps a necessary concomitant of the change, but evidently not the prime object. In tropical regions the heat is not wanted. In the steam-engine, chemical energy is first changed into heat and heat into mechanical energy; in the body the change is, probably, much of it direct and not through the intermediation of heat.

12. We see at once, from the above, why it is that plants cannot feed on elements, viz., because their food must be decomposed in order to create the organic matter out of which all organisms are built. This elevation of matter, which takes place in the green leaves of plants, is the starting-point of life; upon it alone is based the possibility of the existence of the organic kingdom. The running down of the matter there raised determines the vital phenomena of germination of pale plants, and even of some of the vital phenomena of green plants, and all the vital phenomena of the animal kingdom. The stability of chemical compounds, usable as food, is such that a peculiar contrivance and peculiar conditions found only in the green leaves of plants are necessary for their decomposition. We see, therefore, also, why animals as well as pale plants cannot feed on mineral matter.

We easily see also why the animal activity of carnivora is greater than that of herbivora, for the amount of force necessary for the assimilation of their albuminoid food is small, and therefore a larger amount is left over for animal activity. Their food is already on plane No. 4; assimilation, therefore, is little more than a *shifting* on the plane No. 4 from a liquid to a solid condition—from liquid albuminoid of the blood to solid albuminoid of the tissues.

We see also why the internal activity of plants may conceivably be only of one kind; for, drawing their force from the sun, tissue-making is not necessarily dependent on tissue-decay. While, on the other hand, the internal activity of animals must be of two kinds, decay and repair; for animals always draw a portion of their force, and starving animals the whole of their force, from decaying tissue.

13. There are several general thoughts suggested by this subject, which I wish to present in conclusion:

*a.* We have said there are four planes of matter raised one above the other: 1. Elements; 2. Chemical compounds; 3. Vegetables; 4. Animals. Now, there are also four planes of force similarly related to each other, viz., physical force, chemical force, vitality, and will.

4. *Animals.*
3. *Plants.*
2. *Chemical compounds.*
1. *Elements.*

On the first plane of matter operates physical force only; for chemical force immediately raises matter into the second plane. On the second plane operates, in addition to physical, also chemical force. On the third plane operates, in addition to physical and chemical, also vital force. On the fourth plane, in addition to physical, chemical, and vital, also the force characteristic of animals, viz., will.[1] With each elevation there is a peculiar force added to the already existing, and a peculiar group of phenomena is the result. As matter only rises step by step from plane to plane, and never two steps at a time, so also force, in its transformation into higher forms of force, rises only step by step. Physical force does not become vital except through chemical force, and chemical force does not become will except through vital force.

Again, we have compared the various grades of matter, not to a gradually rising inclined plane, but to successive planes raised one above the other. There are, no doubt, some intermediate conditions; but, as a broad, general fact, the changes from plane to plane are sudden. Now, the same is true also of the forces operating on these planes—of the different grades of force, and their corresponding groups of phenomena. The change from one grade to another, as

[1] I might add still another plane and another force, viz., the human plane, on which operate, in addition to all the lower forces, also free-will and reason. I do not speak of these, only because they lie beyond the present ken of inductive science.

from physical to chemical, or from chemical to vital, is not, as far as we can see, by sliding scale, but suddenly. The groups of phenomena which we call physical, chemical, vital, animal, rational, and moral, do not merge into each other by insensible gradations. In the ascension scale in the evolution of the higher forces there are places of rapid paroxysmal change.

*b.* Vital force is transformed into physical and chemical forces; but it is not on that account identical with physical and chemical force, and therefore we ought not, as some would have us, discard the term vital force. There are two opposite errors on this subject: one is the old error of regarding vital force as something innate, underived, having no relation to the other forces of Nature; the other is the new error of regarding the forces of the living body as nothing but ordinary physical and chemical forces, and therefore insisting that the use of the term vital force is absurd and injurious to science. The old error is still prevalent in the popular mind, and still haunts the minds of many physiologists; the new error is apparently a revelation from the other, and is therefore common among the most advanced scientific minds. There are many of the best scientists who ridicule the use of the term vital force, or vitality, as a remnant of superstition; and yet the same men use the words gravity, magnetic force, chemical force, physical force, etc. Vital force is not underived—is not unrelated to other forces—is, in fact, correlated with them; but it is nevertheless a distinct form of force, far more distinct than any other form, unless it be still higher forms, and therefore better entitled to a distinct name than any lower form. Each form of force gives rise to a peculiar group of phenomena, and the study of these to a peculiar department of science. Now, the group of phenomena called vital is more peculiar, and different from other groups, than these are from each other; and the science of physiology is a more distinct department than either physics or chemistry; and therefore the form of force which determines these phenomena is more distinct, and better entitled to a distinct name, than either physical or chemical forces. De Candolle, in a recent paper,[1] suggests the term vital movement instead of vital force; but can we conceive of movement without force? And, if the movement is peculiar, so also is the form of force.

*c.* Vital is transformed physical and chemical forces; true, but the necessary and very peculiar condition of this transformation is the previous existence then and there of living matter. There is something so wonderful in this peculiarity of vital force that I must dwell on it a little.

Elements brought in contact with each other under certain physical conditions—perhaps heat or electricity—unite and rise into the second plane, i. e., of chemical compounds; so also several elements, C, H, O and N, etc., brought in contact with each other under certain

[1] *Archives des Sciences*, vol. xlv., p. 345, December, 1872

physical or chemical conditions, such as light, nascency, etc., unite and rise into plane No. 3, i. e., form organic matter. In both cases there is chemical union under certain physical conditions; but in the latter there is one unique condition, viz., the previous existence then and there of organic matter, under the guidance of which apparently the transformation of matter takes place. In a word, organic matter is necessary to produce organic matter; there is here a law of like producing like—there is an assimilation of matter.

Again, physical force changes into other forms of physical force, or into chemical force, under certain physical conditions; so also physical and chemical forces are changed into vital force under certain physical conditions. But, in addition, there is one altogether unique condition of the latter change, viz., the previous existence then and there of vital force. Here, again, like produces like—here, again, there is assimilation of force.

This law of like producing like—this law of assimilation of matter and force—runs throughout all vital phenomena, runs to the minutest details. It is a universal law of generation, and determines the existence of species; it is the law of formation of organic matter and organic force; it determines all the varieties of organic matter which we call tissues and organs, and all the varieties of organic force which we call functions. The same nutrient pabulum, endowed with the same properties and powers, carried to all parts of a complex organism by this wonderful law of like producing like, is changed into the most various forms and endowed with the most various powers. There are certainly limits and exceptions to this law, however; otherwise differentiation of tissues, organs, and functions, could not take place in embryonic development; but the limits and exceptions are themselves subject to a law even more wonderful than the law of like producing like itself, viz., the law of evolution. There is in all organic nature, whether organic kingdom, organic individual, or organic tissues, a law of variation, strongest in the early stages, limited very strictly by another law—the law of inheritance, of like producing like.

*d.* We have seen that all development takes place at the expense of decay—all elevation of one thing, in one place, at the expense of corresponding running down of something else in another place. Force is only transferred and transformed. The plant draws its force from the sun, and therefore what the plant gains the sun loses. Animals draw from plants, and therefore what the animal kingdom gains the vegetable kingdom loses. Again, an egg, a seed, or a chrysalis, developing to a higher condition, and yet taking nothing *ab extra*, must lose weight. Some part must run down, in order that the remainder should be raised to a higher condition. The amount of evolution is measured by the loss of weight. By the law of conservation of force, it is inconceivable that it should be otherwise. Evidently, therefore, in the universe, evolution of one part must be at the ex-

pense of some other part. The evolution or development of the whole cosmos—of the whole universe of matter—as a unit, according to the doctrine of conservation of force, is inconceivable. It could only take place by a constant increase of the whole sum of energy, i. e., by a constant influx of divine energy.

*e.* Finally, as organic matter is so much matter taken from the common fund of matter of earth and air, embodied for a brief space, to be again by death and decomposition returned to that common fund, so also it would seem that the organic forces of the living bodies of plants and animals may be regarded as so much force drawn from the common fund of physical and chemical forces, to be again all refunded by death and decomposition. Yes, by decomposition; we can understand this. But death! can we detect any thing returned by simple death? What is the nature of the difference between the living organism and a dead organism? We can detect none, physical or chemical. All the physical and chemical forces withdrawn from the common fund of Nature, and embodied in the living organism, seem to be still embodied in the dead until little by little it is returned by decomposition. Yet the difference is immense, is inconceivably great. What is the nature of this difference expressed in the formula of material science? What is it that is gone, and whither is it gone? There is something here which science cannot yet understand. Yet it is just this loss which takes place in death, and before decomposition, which is in the highest sense vital force.

Let no one from the above views, or from similar views expressed by others, draw hasty conclusions in favor of a pure materialism. Force and matter, or spirit and matter, or God and Nature, these are the opposite poles of philosophy—they are the opposite poles of thought. There is no clear thinking without them. Not only religion and virtue, but science and philosophy, cannot even exist without them. The belief in spirit, like the belief in matter, rests on its own basis of phenomena. The true domain of philosophy is to reconcile these with each other.

## HEREDITY AND RACE-IMPROVEMENT.

By FERNAND PAPILLON.

TRANSLATED FROM THE FRENCH BY J. FITZGERALD, A. M.

### II.

So far we have been giving the historical refutation. A more direct and scientific refutation will prove still more decisive and instructive. Having shown that heredity does not exert an exclusive and continuous influence, we must now indicate the causes which act simultaneously with it and in a contrary direction. We have to de-

monstrate the constant and powerful influence of those forces which, as we have said, tend to modify, transform, and complicate man's thoughts, feelings, passions, manners, customs.

The special aim of education is to transmit to the child the sum of those habits to which he is to conform the course of his life, and of those branches of knowledge which are indispensable for him in the pursuit of his calling; and it must begin by developing in the pupil the faculties which will enable him to make these habits and this knowledge his own. It teaches the child to speak, to move about, to look, to use his senses, to hear, to understand, to judge, to love. But now the influence of education, opposed as it is to that of heredity, is so great, that in most cases it is of itself alone capable of producing a moral and psychological likeness between children and parents. If heredity determined irresistibly and infallibly in the descendants the essential characters of their ancestors' personality, education would be superfluous. When once it is admitted that education, a long, watchful, laborious training, is indispensable in order to call forth and perfect in the child the development of aptitudes and of mental qualities, we must conclude that heredity acts only a secondary part in the wonderful genesis of the moral individual. The argument is unassailable. That hereditary influences make their mark in predispositions, in fixed tendencies, it were unscientific to deny; but yet it would be inexact to pretend that they implicitly contain the future states of the psychical being, and determine its evolution.

There is nothing more complex than education, nor must we think here of studying its general economy, which has been the theme of so many books. The importance which is generally attributed to works on pedagogy is of itself a protest against the abuse of hereditarian theories. Some fresh details as to one of the chief agencies in education, viz., the instinct of imitation, and the part it plays in the development of individuals and of races, will suffice to demonstrate the energy of certain influences which have nothing to do with heredity.

An accomplished English historian, Bagehot, recently published some excellent observations, which go to show what great influence is exerted in the formation of customs and of tastes, and also how their periodic revolutions are explained, by the unconscious imitation of a favorite character or type, and by the general favor accorded to the same. According to him, a national character is only a local character which has been favored by fortune, precisely as a national language is only the definitive extension of a local dialect. There is nothing more undoubted than the force of this tendency to imitation. It is in virtue of this that certain processes in manufacture, art, literature, manners, discovered under peculiar circumstances, attain a general ascendency, and are rapidly imposed, first upon the docile and unthinking multitude, and then on those who possess all the means of inquiry and resistance. Here it may be observed that the *élite* are almost always

constrained to follow the tastes and the judgments of the masses, under penalty of being ignored or contemned. A writer devises a style which the public receive with enthusiasm: he has struck a vein. He accustoms those who read his books, or who witness his plays, to this style, be it good or bad, and the result is that, for some time, all authors are compelled more or less to imitate the fortunate innovator, if they wish to succeed. Hence, though one were not led to imitate, by instinct or by nature, still he would do so from necessity or from self-interest. The founder of the London *Times* was once asked how he contrived to have all the articles in that journal appear as though written by one hand. "Oh," said he, "there is always one editor who is superior to all the rest, and they imitate him."

The history of religions from beginning to end is full of facts showing how men are guided, not by arguments but by exemplars, and exhibiting the tendency they have to reproduce what they have seen or heard, and to regulate their lives according to the bright and triumphant examples that stand before their eyes. Many victories, esteemed by apostles to be the effects of persuasion, are rather to be attributed to that recondite influence which leads men irresistibly to imitate their fellows. And does not this same agency of imitation appear in the body politic, transforming little by little, but yet radically, the habits, the opinions, and even the beliefs of men? Nothing is easier, than, for a man who has acquired an influence over the populace, to bring them over to his own sentiments, ideas, and chimeras. And the observation is confirmed by daily experience in the education of children. In a school we often find the external characteristics—the tone, the gait, the games, changing from year to year. The reason of this is that some dominant spirits—two or three pupils who used to have an ascendency over the rest, have left; others are now in their place, and every thing wears a different face. As the models change, so do the copies. The pupils no longer applaud or jeer at the same things as before.

This instinct of imitation is specially developed in persons of defective education or civilization. Savages copy quicker and better than Europeans. Like children, they have a natural faculty for mimicry, and cannot refrain from imitating every thing they see. There is in their minds nothing to offset this tendency to imitation. Every well-instructed man has within himself a considerable reserve of ideas upon which to fall back; this resource is wanting in the savage and in the child: they live in all the occurrences which take place before them; their life is bound up in what they see and hear; they are the playthings of external influences. In civilized nations persons without culture are in the like situation. Send a chambermaid and a philosopher into a country, the language of which neither of them is acquainted with, and it is likely that the chambermaid will learn it before the philosopher. He has something else to do: he can live with his

own thoughts; as for her, if she cannot talk, she is undone. The instinct of imitation is in an inverse ratio to the power of mental abstraction.

From these details it will be seen that this strong instinctive force of imitation, which plays so important a part in the education of individuals and of races, is a very different thing from heredity. It may and it does act in concert with hereditary impulsions; but far more frequently it works independently and even in a direction counter to them. And the same is to be said of another force—a more determined rival still, and a more puissant antagonist of heredity, viz., personality, whose functions we have next to consider.

The individual personality of the soul, which is preëminently the instrument of free inventiveness and the unfailing spring of the innovative faculty, might, in contrast with heredity, be called spontaneity.[1] To give a notion of the power of spontaneity, as compared with that of heredity, we might draw up lists exhibiting cases in which the manifestation of various passions or talents does not come from ancestry, and in which the individual is born different from his parentage, or distinguishes himself from them by the reaction of his own will. Such lists would be endless; for, the opinion of the partisans of absolute heredity to the contrary notwithstanding, spontaneity and personal activity are the rule in the development of the mind. In short (and this is the main point), heredity has its root in spontaneity; for, after all, those aptitudes, those qualities, which parents transmit to their children, must necessarily have originated, at some time, from the spontaneous action of a more or less independent will. We hear of idiots, and of hysterical and epileptical subjects, or, on the other hand, of painters, musicians, and poets, who derive from their parentage the sinister or the beneficent activities which characterize them. True enough; but the question for us is, Whence did the parents themselves derive this activity? In taking a retrospective view of the *ascendants*, we must reach the point where spontaneity is preëminent; and this preëminence is all the less questionable in proportion as it reappears in the descendants. The effects of heredity appear and disappear; at first, they overmaster spontaneity, suspending its influence; then they are exhausted, and spontaneity again reclaims its rights. Thus spontaneity is a continuous, persisting force, while heredity is intermittent and transitory. Human nature, considered in its progress from age to age, is a succession of independent minds, all the more independent in proportion as they have less need of the concurrence of mechanical or organic powers in willing and acting. Where they require such concurrence, a portion of their innate independence is surrendered to the blind influences of heredity. And yet, even as regards the origin of æsthetic aptitudes, spontaneity is the stronger of the two.

[1] Spontaneous. *Produced without being planted.*—(Webster.) *Native, innate.*

In studying the history of illustrious men, how often do we find brilliant imagination and extraordinary capacity for art, poetry, and literary composition, which are by no means the result of heredity. We have not far to go for instances of this. Lamartine, Alfred de Musset, Meyerbeer, Ingres, Delacroix, Mérimée, displayed talents for which they were in no wise indebted to their parentage. The history of men of science exhibits the part played by heredity still further cut down. We are told of families of *savants*. How many of these might be enumerated? A dozen at the most. On the other hand, how many illustrious *savants* there are, among whose ascendants are found only people of very common stamp, or else distinguished for talents of a very different order from those which characterize the man of science! What hereditary influences fashioned a Cuvier, a Biot, a Fresnel, a Gay-Lussac, an Ampère, a Blainville? It is plain that in these instances spontaneity and education enacted the chief part. Nor does the history of authors agree any better with the pretensions made by the thorough partisans of heredity.

It is especially among philosophers that spontaneity appears to be supreme. Our authors present no lists of philosophers who have inherited from their ancestors the talent for speculation. Here we have a series of facts which make against heredity; these its advocates say nothing about, nor indeed are they made sufficient account of by either party. Metaphysicians, precisely because in them the mental element alone is active, are exempt from all the influences of heredity. In proportion as the characters it tends to transmit are less of a physiological and more of a psychological nature, the less is the influence of heredity. But there is nothing more purely psychological, or more free from sense-elements and mechanical factors, than the mind of the speculative philosopher. In point of fact, the great metaphysicians had no progenitors, nor did they leave any posterity. The philosophic genius has ever been absolutely individual, inalienable, and intransmissible. There is not a single great thinker, in whose line, whether ascending or descending, we discover either the promise or the perpetuation of the high capacities which made him illustrious. Descartes and Newton, Leibnitz and Spinoza, Diderot and Hume, Kant and Maine de Biran, Cousin and Jouffroy, had neither ancestors nor posterity.

Such is spontaneity. To form a precise idea of the part it plays, we should have to determine, in a general way, and also in relation to temperament, education, social and other conditions, etc., the genesis and development of those faculties by which a given man of superior power is distinguished from his progenitors; we must group together and classify the characteristic elements which make up the very essence of the personality and individuality—those marvelous elements of free initiative and of total independence which stamp a man as a genius. It would then be seen that most commonly superior abilities

are so native to those who display them, so deep seated and endowed with a life of their own, that education and training, instead of calling them forth, serve rather to check their development. In a man of genius we should discern self-reliant precocity, a passion for enterprise, a strong belief in his mission, a pride lifting him above sect-prejudice or party ambitions, and attaching him exclusively to the object of his meditations, for which alone he values life. Even when temporal necessities compel him to take part in the transactions of men, the world is for him only a peopled wilderness, where his soul lives in solitude.

The materials for such a study exist in part; they are to be found in biographies written during the last two hundred years, by the secretaries of the great academies, and in the autobiographic memoirs left by several illustrious men. An ingenious and learned Russian writer, Wechniakof, has lately published sundry works, in which he considers, from this point of view, the anthropological and sociological peculiarities which have had an influence in the individual development of original genuises. Unfortunately, these opuscles do not form a complete treatise, and yet a treatise on spontaneity would be a very curious and very useful work.

The aggregate of all the causes of diversity, heterogeneity, and innovation, which in man act in opposition to the principles of simplicity, homogeneity, and conservation, we may designate by one name, viz., evolution or progress. Regarded within the limits of positive observation, blind Nature has been ever the same. It is to-day, on the whole, what it was in Homer's time: the same sky, oceans, mountains, forests, flowers. Man, on the other hand, is ever undergoing transformation. Generations succeed one another, but are unlike. They are in a state of constant and rapid metamorphosis in their faiths, their knowledge, their arts, their wants. Nations, like individuals, grow up and decay. But the face of Nature is unchanged: as Byron says of Greece:

> "Yet are thy skies as blue, thy crags as wild;
> Sweet are thy groves, and verdant are thy fields,
> Thine olive ripe as when Minerva smiled,
> And still his honeyed wealth Hymettus yields;
> There the blithe bee his fragrant fortress builds,
> The free-born wanderer of thy mountain air;
> Apollo still thy long, long summer gilds,
> Still in his beam Mendeli's marbles glare;
> Art, glory, freedom fail, but Nature still is fair."

We might multiply *ad infinitum* these historic contrasts between the immutability of the universal fatalism which reigns in Nature, and the incessant movement of liberty and invention in man, together with the ceaseless striving of the soul to free itself from the grip of Fate. History is but the record of what has resulted during ages

from this movement, from this striving. It is a protracted drama, where the good genius of liberty contests the throne with the evil genius of brute force, and where, under the eye of God, and with his assistance, is won, slowly and laboriously, the victory of mind, which searches, discovers, invents, creates, loves, adores!

III.

In the first part of this essay we established the facts of heredity, and showed the part it plays in reproducing physiological and psychological characteristics. In the second we pointed out and examined the causes which run counter to the more or less tyrannical impulsions of Nature, and to mechanical necessities. We have now to state some practical conclusions as to the use that may be made of this knowledge in perfecting the race.

The heroic combatants of Homer's epic invoked the names of their fathers and ancestors, and were proud of their noble blood. It was a high instinct, and they who can justly boast of their forefathers will always be in a position to earn for themselves the respect of their children. In short, the phenomena of heredity authorize the belief that parents of well-constituted body and mind are most likely to transmit to their posterity their own likeness.

What measures are to be taken, then, to bring about happy alliances, such as will produce offspring of high excellence in a physical and moral point of view? This is a very delicate question, and we can give only a summary reply to it, based chiefly on an unpublished work by the eminent surgeon, M. Sédillot, who devotes the leisure time of his honorable retirement to studying the means of perfecting the race. First of all, M. Sédillot thinks that we may obtain valuable information as to an individual's real value by consulting his genealogy: the history of his ascendants for four or five generations, with special reference to intellect, morality, vigor, health, longevity, social status, virtually contains a portion of his own history. Long before Gall the fact was established (nor was it overturned by Gall's exaggerations) that the form of the head is, in some measure, an index of a man's mental calibre. From the remotest antiquity, the popular mind has observed the relation which subsists between great size of head and superior abilities; and language is full of expressions which witness to the correctness of this relation. Pericles excited the astonishment of the Athenians by the extraordinary volume of his head. Cromwell, Descartes, Leibnitz, Voltaire, Byron, Goethe, Talleyrand, Napoleon, Cuvier, etc., had very large heads. Cuvier's brain weighed 1,829 grammes, the average weight of Europeans' brains being, according to Broca, from 1,350 to 1,400 grammes. M. Sédillot regrets that we do not possess measurements of the various cranial dimensions of men distinguished for certain capacities, so that we might ascertain the important relations which subsist between these dimensions and

these capacities; and he expresses the wish that such measurements should be taken. But at least we know, in a general way, what characters and what cranial dimensions correspond with the various degrees of cerebral activity. Most anthropologists hold that the man whose head has not an horizontal circumference of 50 centimetres (19.685 inches) is almost inevitably a person of only mediocre ability, and that the one in whom this circumference attains or surpasses 58 centimetres (22.8346 inches) is likely to be a very superior man. Instances are cited, it is true, of celebrated personages with small heads; but in such case the individuals gained distinction in some very narrow specialty. It must not be forgotten that these dimensions constitute but one of the external indices which enable us to determine approximately the intellectual value of an individual. We have also to take account of the general form and relative proportions of the various regions of the cranium, i. e., of that harmony which is called beauty. An easy means, according to M. Sédillot, of studying the conformation of the head, is by taking a side or profile view of it, a little back of the forehead. One then instantly perceives the ratio between the height and breadth of the forehead and temples and the face, and a clear perception is got of the relative proportions of the anterior or frontal, and the posterior or occipital contours of the head. The individual who has the superciliary arches prominent, the temples bare, nearly vertical and high, with broad, high forehead, and features expressive neither of an unbalanced nor of a torpid mind, may in general be regarded as a truly human type, and as possessed of a mind that is fitted to do honor to the race. The story goes, that once a certain Englishman sent his groom to the ale-house in search of his friend Shakespeare. "How shall I know him?" quoth the groom. "The easiest thing in the world," replied his master; "everybody, more or less, resembles some animal; but, when you lay eyes on Shakespeare, you will at once say, 'There is a man!'" Man in the fullness of his harmonious beauty, such is the ideal toward which all the efforts of our present imperfect humanity ought to be directed, and it is full time that we should strive, by a wise use of the principle of heredity, i. e., by healthy procreation, to develop a human race in which the last traces of animality shall have disappeared, and in which the *Man* shall be less rare.

What is it that constitutes the superiority of the English aristocracy? Their constant study to endow their descendants with the best bodily, intellectual, and moral qualities. The Englishman does not marry from caprice or from passion; he marries under the conditions which are best fitted to insure the welfare of his children, for he knows that on their welfare his own happiness, his honor, and his name depend. The respect shown to young Englishwomen, the honorable liberty they enjoy, the secondary importance that is attached to their fortune, and the stress that is laid on their personal worth, are all so many

causes increasing among that people the number of happy marriages, and consequently giving vigor to the population. This is one of the grand secrets of race-improvement by heredity. Instead of looking for wealth, men must look for beauty, character, and virtue. So long as they persist in forming alliances with women of feeble constitution, or lacking essential qualifications, the race will decline and degenerate. And, of course, the same deplorable consequences follow from the marriage of noble and well-organized women with men of inferior type. Fortunately, the tact and the instinctive dignity of women, and their natural liking for what is exalted, usually prevent their descending to debasing or dangerous alliances, and nearly always guard them against ill-assorted matches. "In place of giving way to sympathetic emotions," says M. Sédillot, "which disorder the judgment, let one put himself the question, on seeing a person that pleases him, if he wants to have sons and daughters of that same type; and it is curious to note how often the reply will be in the negative. It were unreasonable, no doubt, to forego present advantage for the sake of some uncertain advantage in the future; still, wisdom requires us to bring the two into harmony, and to remember how swiftly time passes away, and how little is the value of the passing hour, as compared with the hopes and the enjoyments of the future." M. Sédillot adds that, in ordinary times, hygiene, the moral evidence of the advantages of health and intelligence, would suffice for the regeneration of a people. France, unfortunately, has need of stronger and more efficacious agencies; she must go back to the very fountain-head of regeneration and of life, that is to say, must discover the speediest means of insuring to the coming generations a future of virtue and mettle. In other times it may have appeared difficult or ill-advised to import, into questions touching the reproduction of man, figures and estimates not unlike those employed in zootechny, where selection has long been practised. But now such scruples must give way before the dictates of necessity, which tells us in the most unmistakable way that we cannot afford to commit one blunder more.

Here we have to point out the means of staying or of reducing as far as possible the fatal heredity of disease, which is so powerful an obstacle to the improvement of the race. The preventive or prophylactic agencies which are to be employed to counteract the evolution of disease-germs depend, of course, on the nature of these latter. A consumptive mother must not suckle her infant; she ought to intrust it to the care of a good nurse. Those whose parents were affected with chest-diseases thrive but ill on an excessively animal diet: a regimen of *white meats* and light foods is best suited for them. As regards occupation, they should carefully avoid all such as would expose them to inhale dust, or to undergo alternations of heat and cold, or to use the voice habitually. Residence by the sea-side, in the south, and in localities where consumption is of rare occurrence,

is the best prophylactic against this fearful disease. Individuals predisposed to scrofula require pure air, substantial tonic diet, and an atmosphere like that on the sea-coast of Northwestern Europe. Those who are threatened with gout or gravel must oblige themselves to the strictest temperance and take abundant exercise. Regularity and uniformity of life are the rule for those predisposed to cancer. Persons who reckon epileptics among their ascendants require the utmost care. All their functions must be tranquillized; they must allow themselves no excesses; must avoid fatigue; must guard against emotional excitement—in a word, they must be always surrounded with tranquillizing influences. Those predisposed to insanity are to be treated in a similar manner, that is to say, with great gentleness; and their passions are to be stilled. The course of life best suited to them is one which does not call for much intellectual activity, and which holds out no visions of fame or fortune. Preventing or checking in the individuals themselves the development of disease-germs is, however, but a secondary consideration; the chief point is, to prevent the migration of these germs into new generations. But, to attain this result, we must not only multiply and facilitate marriages which shall be in conformity with hygienic and moral laws, we have furthermore to discourage alliances the fruits of which can only be of blighted constitution in body and soul. Physicians ought to use all their influence to prevent the intermarriage of persons evidently predisposed to the various forms of neurosis, to tubercle, scrofula, etc. When the ascendants of one of the parties are hereditarily of a morbid constitution, the physician should at least insist on the importance of having the other party perfectly healthy, possessed of great vigor, and, above all, of a temperament the reverse of that of his or her partner. In this way the danger of hereditary taint is diminished, though it were better not to incur such danger at all. But this is a point of so delicate a nature that we cannot dwell upon it here. We must, however, say something about consanguineous marriages, a subject which has given rise to much warm controversy during the past few years. Some physicians, and among them Broca and Bertillon, hold that races which are least mixed, which are purest, are better fitted than crossed races to withstand the causes of degeneracy. According to them, the evil consequences charged on consanguinity are the result of very different agencies, especially the hereditary affections of the ascendants. Trousseau and Boudin, on the other hand, say that marriages between individuals of the same stock oftentimes yield unhealthy fruits—lunatics and idiots. The balance would appear to have been struck in favor of the first opinion. It was but the other day, that Auguste Voisin, in making inquiries of the relatives of more than 1,500 patients in the Bicêtre and the Salpêtrière, found that in none of these cases could the disease be attributed to consanguinity. If the latter had been so infallible a cause of degeneracy,

its effects would have been seen in that large number of madmen and idiots.

Although theorizers have exaggerated the influence of heredity, it cannot be denied that it plays a part in the genesis of temperament and character, and here we have a warrant for the employment of every means that will favor the transmission of the most desirable aptitudes. In ancient Rome, women of the highest distinction, who were respected by all, imported into another family, with their husbands' consent, their superiority of blood. Quintus Hortensius, the friend and admirer of Cato, having failed to win his daughter Portia, asked for his wife Marcia, and Cato gave her to him. The grossness of such customs shocks our finer sense, but its explanation is to be found in the anxiety of a Roman head of a family to insure for his descendants the highest grade of masculine vigor, and the most solid virtues.

Under the old constitution of society in France, the tenure of high offices and trusts, and the following of some special profession by one family from generation to generation, had their rise and bases in the unconscious observation that aptitudes are hereditary; and M. Sédillot regrets that the revolutions of modern society have done away with this wholesome tradition, which, in every grade of the social scale, morally constrained the son to follow in his father's steps. This point must not be overlooked by races which care for self-improvement.

Another point for such races to bear in mind, and one of readier application, is the necessity of a sound and enlightened system of education. On this topic, those who have the future of France at heart, have but one opinion, viz., that the coming generations must be invigorated by giving more prominence to bodily exercise, and by exempting children from employments injurious to health. They have no thought of interfering with classical studies or the humanities, which will continue to be the chief element in moral culture; the only question is, whether the young could not acquire the treasures of Latinity and Hellenism in less time, and bestow some little study on matters of modern interest. There are sundry branches in which they now obtain no instruction, but which they might study much to the advantage of their intellectual development. This is not the place to enforce this argument; but it does seem unquestionable that, by means of a thorough system of education, proceeding on new principles, we might be able, if not exactly to change the whole character of a people, as Leibnitz thought, at least to do away with most of the influences which, for want of suitable training, cause them to fall into decay.

The conviction that it is possible to counteract the dangerous impulsions of heredity and to triumph over the tyrannies of Fate—at least to acquire a moral superiority over them—is a most wholesome one to spread abroad and to bring into acceptance. A strong will is in itself a power. Even though it were not so easy a thing as it is, to prevail

over the blind forces of Nature, simply by the overmastering power of a resolute and sagacious will, there would still exist abundant grounds for believing that man has the power of modifying and amending his own conduct; that he is not the plaything of inflexible Destiny; and that he may not give way, without resistance or remorse, to his evil instincts. Let us believe in heredity, in so far as it may be made a means of improvement and of free perfectionment. But let us withhold our assent when there is claimed for it a despotic power so absolute as it would be madness to resist. Education has not only to improve the race, but also to give men a desire for improvement, by showing them that it is possible. In alliance with a judicious cultivation of desirable hereditary tendencies, education overmasters noxious proclivities and regenerates the race.

We must not, however, attribute to education an exaggerated importance, nor imagine that by itself alone it can call forth preëminent ability. Its influence, like that of heredity, is limited. Genius, which is the most perfect expression of mind, considered as a free creative force, is controlled by neither. It is a mighty tree whose fruits give sustenance to generations, and the conditions of whose growth are such that we can no more foresee or determine its appearing than we can prescribe rules for its behavior afterward, or estimate its fruitfulness. Fortunately, geniuses are not indispensable, and, in proportion as the national average rises, the less need is there for them. But the general average rises of necessity when all the citizens are animated with the one desire of improvement. Hereditary cultivation, proceeding by means of a rigid selection of the influences which tend to improve the race, may be confidently commended to those nations who are ambitious of holding the first rank in the world.—*Revue des Deux Mondes.*

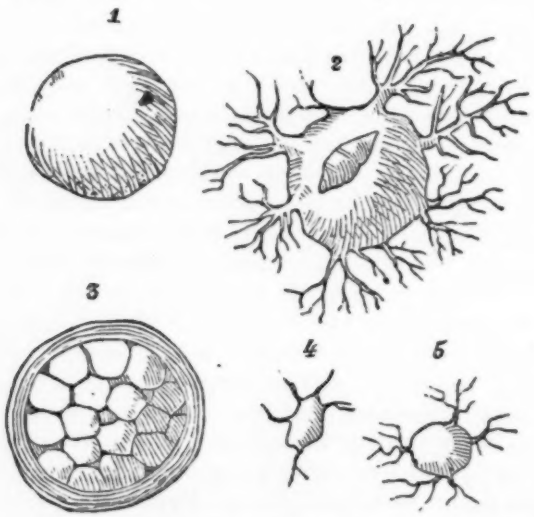
## HÄCKEL'S MONERS.

By AIME SCHNEIDER.

THE moners are the simplest organisms we know of—we might even say, the simplest that can exist. In them, life is exhibited under the form that is best fitted to give us an idea of its essential characters, stripped of all secondary attributes. The first moner was discovered by the celebrated Prof. Häckel, of Jena, in 1864, and the number has gone on steadily increasing ever since. These discoveries have made a great stir in the scientific world, owing to their bearing on our theories of organization.

The moner which best typifies the entire class is the *Protomyxa aurantiaca.* This little creature, hardly visible to the naked eye, and, at most, as big as a small pin-head, is of a fine orange-red color, con-

sists of a perfectly homogeneous and transparent mass of jelly, and offers the paradox of *an organism without organs*. Nor is this absence of organs merely apparent, or owing to the imperfection of our magnifying-glasses; it is real, and every thing about these little creatures goes to prove their perfect simplicity of structure. This gelatinous, homogeneous, contractile substance has been called *sarcode*, and also, but improperly, *animal protoplasm*.




HISTORY OF THE PROTOMYXA AURANTIACA, ACCORDING TO HÄCKEL.

1. The moner in a state of repose.
2. The same sending forth its pseudopodes and embedding a foreign body in itself.
3. The same in process of reproduction, after having exuded its envelope, and split up into a number of spherical masses.
4. A young moner set free after the bursting of the envelope.
5. The same in a more advanced stage, with its pseudopodes.

In repose, the moner is nearly spherical, and gives no sign of life. But soon this little ball flattens itself out, its mass expands in various directions, and these expansions, which have received the name of *false feet*, or *pseudopodes*, keep up a continual movement of protrusion and retraction. Sometimes the moner *flows* all in one direction, and this is its way of moving from place to place. When, in the course of this slow progress over the calcareous slime of the sea-bottom, the moner falls in with one of those microscopic organisms called diatoms, it embeds it in its own body; the alimentary substances contained in the diatom are dissolved and assimilated, and the indigestible portions are left behind as the creature moves along. Thus, we have the curious phenomenon of a creature which feeds without mouth, without stomach, without apparatus of any kind, simply by incorporating into itself, as it moves, prey of every kind. In taking food, the animal appears to be passive, its seizing on its prey being a mere incident of its moving about.

In this way, the moner attains by degrees a certain size, and then stops growing and moving. It then becomes a little ball, exudes from its surface a colorless, homogeneous matter which hardens, forming a protecting envelope for the inclosed mass. Then, a very singular phenomenon occurs: by an act entirely spontaneous, the inclosed mass breaks up into a certain number of parts, which soon become independent, constituting so many little spherical masses lying side by side within the common envelope. The original moner then exists no more; it has reproduced itself by dividing itself up, without any intermediary, into these new individuals, its progeny. Each young moner is a determinate part of the mother-animal, and, leaving out of consideration what she exuded to form the envelope, all the rest of her substance is exempted from death, and is now to begin a new life, which in turn will pass through the series of transformations already described. The envelope will soon break up and set at liberty the young moners, which, from the first, resemble the mother-animal.

At the grade of extreme simplification of life presented to us in the moner, we have organization reduced to pure sarcode, and life manifesting itself by nutrition, reproduction, and contractility, each reduced to its barely essential function—nutrition reduced to mere assimilation, reproduction to a spontaneous fission into a group of young (fissiparity), and contractility to the slow, diffusive movements of the pseudopodes.

Moners are mostly inhabitants of the sea. Some of them live at inconsiderable depths; but there is one, the *Bathybius Häckelii*, which lives at the enormous depth of 12,000 feet, and sometimes even of more than 24,000 feet. There is only one fresh-water moner.

Many naturalists rank moners among animals, classing them as rhizopods. Häckel, who discovered them, regards them as the representatives of an entire category of beings intermediate between animals and plants, the *protista*, so called from *protos* (first), because, according to this author, they are the first representative of terrestrial life, from which all other forms of life are developed, on the modern theories of Darwinism.—*La Nature.*

## A NEW METHOD WITH THE BRAIN.[1]

By Professor FERRIER.

ALL are agreed that it is with the brain that we feel, and think, and will; but whether there are certain parts of the brain devoted to particular manifestations, is a subject on which we have only imperfect speculations or data too insufficient for the formation of a scientific opinion. The general view is that the brain as a whole sub-

[1] A paper read before the Biological Section of the British Association.

serves mental operations, and that there are no parts specially devoted to any particular functions. This has been recently expressed by so high an authority as Prof. Séquard. The idea rests chiefly on the numerous facts of disease with which we are acquainted. There are cases where extensive tracts of brain are destroyed by disease, or removed after a fracture, apparently with no result as regards the mind of the individual. Along with these facts we have others which are very curious, and which hardly seem to agree with this doctrine. One of these is, that when a certain part of the brain is diseased, in aphasia, the individual is unable to express himself in words. Other curious phenomena have been well described by Dr. Hughlings Jackson, viz., that certain tumors or pathological lesions in particular parts of the brain give rise, by the irritation which they keep up, to epileptiform convulsions of the whole of one side, or of the arm, or leg, or the muscles of the face; and, from studying the way in which these convulsions show themselves, he was able to localize very accurately the seat of the lesion.

The great difficulty in the study of the function of the brain has been, in the want of a proper method. When we study the function of a nerve, we make our experiments in two ways: In the first place, we irritate the nerve by scratching or by electricity, or by chemical action, and observe the effect; and, in the second place, we cut the nerve, and observe what is lost. In regard to the brain and nervous system, the method has been almost entirely, until recently, the method of section. It has been stated by physiologists that it is impossible to excite the brain into action by any stimulus that may be applied to it, even that of an electric current; they have, therefore, adopted the method of destroying parts of the brain. This method is liable to many fallacies. The brain is such a complex organ, that to destroy one part is necessarily to destroy many other parts, and the phenomena are so complex, that one cannot attribute their loss to the failure only of the parts which the physiologists have attempted to destroy.

About three years ago, two German physiologists, Fritsch and Hitzig, by passing galvanic currents through parts of the brains of dogs, obtained various movements of the limbs, such as adduction, flexion, and extension. They thus discovered an important method of research, but they did not pursue their experiments to the extent that they might have done, and perhaps did not exactly appreciate the significance of the facts at which they had arrived.

I was led to the experiments which I shall have to explain, by the effects of epilepsy and of chorea, which have been explained to depend upon irritation of parts of the brain. I endeavored to imitate the effects of disease on the lower animals, and determined to adopt the plan of stimulating the parts of the brain by electricity, after the manner described by Fritsch and Hitzig.

I operated on nearly a hundred animals of all classes—fish, frogs,

fowls, pigeons, rats, Guinea-pigs, rabbits, cats, dogs, jackals, and monkeys. The plan was to remove the skull, and keep the animal in a state of comparative insensibility by chloroform. So little was the operation felt, that I have known a monkey, with one side of the skull removed, awake out of the state induced by the chloroform, and proceed to catch fleas, or eat bread-and-butter. When the animal was exhausted, I sometimes gave it a little refreshment, which it took in the midst of the experiments.

First, as to the experiments on cats, I found that, on applying the electrode to a portion of the superior external convolution, the animal lifted its shoulder and paw (on the opposite side to that stimulated) as if about to walk forward; stimulating other parts of the same convolution, it brought the paw suddenly back, or put out its foot as if to grasp something, or brought forward its hind-leg as if about to walk, or held back its head as if astonished, or turned it on one side as if looking at something, according to the particular part stimulated. The actions produced by stimulating the various parts of the middle external convolution were, a drawing up of the side of the face, a backward movement of the whiskers, a turning of the head, and a contraction of the pupil, respectively. A similar treatment of the lower external convolution produced certain movements of the angles of the mouth; the animal opened the mouth widely, moved its tongue, and uttered loud cries, or mewed in a lively way, sometimes starting up and lashing its tail as if in a furious rage. The stimulation of one part of this convolution caused the animal to screw up its nostrils on the same side; and, curiously enough, it is that part which gives off a nerve to the nostril of the same side.

Results much of the same character were produced by the stimulation of the corresponding or homologous parts of the rat, the rabbit, and the monkey. Acting upon the anterior part of the ascending frontal convolution, the monkey was made to put forward its hand as if about to grasp. Stimulation of other portions acted upon the biceps, and produced a flexing of the forearm, or upon the zygomatic muscles. The part that appeared to be connected with the opening of the mouth and the movement of the tongue was homologous with the part affected in man in cases of aphasia. Stimulation of the middle temporo-sphenoidal convolution produced no results; but the lower temporo-sphenoidal, when acted upon, caused the monkey to shut its nostrils. No result was obtained in connection with the occipital lobes.

These experiments have an important bearing upon the diagnosis in certain kinds of cerebral disease, and the exact localization of the parts affected. I was able to produce epileptic convulsions of all kinds in the animals experimented upon, as well as phenomena resembling those of chorea or St. Vitus's dance. The experiments are also important anatomically, as indicating points of great significance in reference to the homology of the brain in lower animals and in man, and like-

wise served to explain some curious forms of expression common to man and the lower animals. The common tendency, when any strong exertion is made with the right hand, to retract the angle of the mouth and open the mouth on the same side, had been stated by Oken, in his "*Natur-geschichte*," to be due to the homology between the upper limbs and the upper jaw; the true explanation being that the movements of the fist and of the mouth are in such close relation to each other that, when one is made to act powerfully, the impression diffuses itself to the neighboring part of the brain, and the two act together.

The experiments have likewise a physiological significance. There is reason to believe that, when the different parts of the brain are stimulated, ideas are excited in the animals experimented upon, but it is difficult to say what the ideas are. There is, no doubt, a close relation between certain muscular movements and certain ideas, which may prove capable of explanation. This is supported by the phenomena of epileptic insanity. The most important guide on the psychological aspect of the question is the disease known as aphasia. The part of the brain which is the seat of the memory of words is that which governs the movements of the mouth and the tongue. In aphasia, the disease is generally on the left side of the brain, in the posterior part of the inferior frontal convolution, and it is generally associated with paralysis of the right hand, and the reason might be supposed to be that the part of the brain affected is nearly related to the part governing the movements of the right hand.

It is essential to remember that the movements of the mouth are governed bi-laterally from each hemisphere. The brain is symmetrical, and I hold it to be a mistake to suppose that the faculty of speech is localized on the left side of the brain. The reason why an individual loses his speech when the left side of the brain is diseased is simply this: Most persons are right-handed, and therefore left-brained, the left side of the brain governing the right side of the body. Men naturally seize a thing with the right hand, they naturally therefore use rather the left side of the brain than the right, and when there is disease, there the individual feels like one who has suddenly lost the use of his right arm.

I may, finally, briefly allude to the results of stimulating the different ganglia. Stimulation of the corpora striata causes the limbs to be flexed; the optic thalami produces no result: the corpora quadrigemina produce, when the anterior tubercles are acted upon, an intense dilatation of the pupil, and a tendency to draw back the head and extend the limbs as in opisthotonos; while the stimulation of the posterior tubercles leads to the production of all kinds of noises. By stimulating the cerebellum, various movements of the eyeballs are produced.—*Nature.*

# MARS, BY THE LATEST OBSERVATIONS.

FROM THE FRENCH OF CAMILLE FLAMMARION.

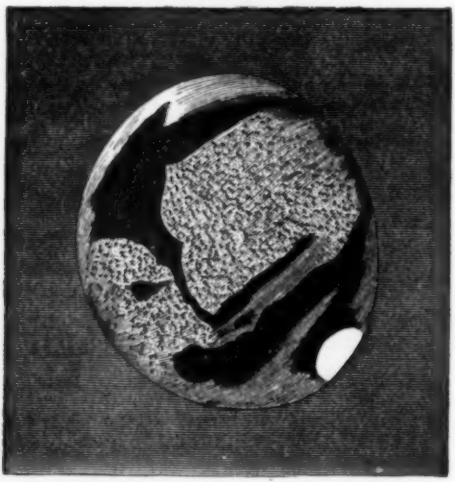
IN order successfully to observe Mars, two conditions are requisite: First, the earth's atmosphere must be clear at the point of observation; and, second, the atmosphere of Mars must be also free from clouds—for that planet, like the earth itself, is surrounded by an aërial atmosphere which from time to time is obscured by clouds just like our own. These clouds, as they spread themselves out over the continents and seas, form a white veil which either entirely or partially conceals from us the face of the planet. Hence the observation of Mars is not so easy a matter as it might at first appear. Then, too, the purest and most transparent terrestrial atmosphere is commonly traversed by rivers of air, some warm, some cold, which flow in different directions above our heads, so that it is almost impossible to sketch a planet like Mars, the image seen in the telescope being ever undulating, tremulous, and indistinct. I believe that, if we were to reckon up all the hours during which a perfect observation could be had of Mars, albeit his period of opposition occurs every two years, and although telescopes were invented more than two and a half centuries ago, the sum would not amount to more than one week of constant observation.

And yet, in spite of these unfavorable conditions, the Planet of War is the best known of them all. The moon alone, owing to its nearness to us, and the absence of atmosphere and clouds, has attracted more particular and assiduous study; and the geography (selenography[1] rather) of that satellite is now satisfactorily determined. That hemisphere of the moon which faces us is better known than the earth itself; its vast desert plains have been surveyed to within a few acres; its mountains and craters have been measured to within a few yards; while on the earth's surface there are 30,000,000 square kilometres (sixty times the extent of France), upon which the foot of man has never trod, which the eye of man has never seen. But, after the moon, Mars is the best known to us of all the heavenly bodies. No other planet can compare with him. Jupiter, which is the largest, and Saturn the fullest of curious interest, are both far more important than Mars, and more easily observed in their *ensemble*, owing to their size; but they are enveloped with an atmosphere which is always laden with clouds, and hence we never see their face. Uranus and Neptune are only bright points. Mercury is almost always eclipsed, like a courtier, by the rays of the sun. Venus alone may compare with Mars; she is as large as the earth, and consequently has twice the

[1] *Selene*, the moon.

diameter of Mars; besides, she is nearer to us, her least distance being about 30,000,000 miles. But, one objection is, that Venus revolves between the sun and us, so that, when she is nearest, her illuminated hemisphere is toward the sun, and we see only her dark hemisphere edged by a slight luminous crescent, or, rather, we do not see it at all. Hence it is that the surface of Venus is harder to observe than that of Mars, and hence, too, it is that Mars has the preëminence, and that in the sun's whole family he is the one with which we shall first gain acquaintance.

FIG. 1.



ASPECT OF MARS, WITH ITS CAP OF POLAR SNOW.

The geography of Mars has been studied and mapped out. What principally strikes one on studying this planet is that its poles, like those of the earth, are marked by two white zones, two caps of snow, one of which is shown in the cut. Sometimes both of these poles are so bright that they seem to extend beyond the true bounds of the planet. This is owing to that effect of irradiation which makes a white circle appear to us larger than a black circle of the same dimensions. These regions of ice vary in extent, according to the season of the year; they grow in thickness and superficial extent around both poles in the winter, melting again and retreating in the summer. They have a larger extension than our glacial regions, for sometimes they descend as far as Martial latitude 45°, which corresponds with the terrestrial latitude of France.

This first view of Mars shows an analogy with our own planet, in the distribution of climates into frigid, temperate, and torrid zones. The study of its topography will, on the other hand, show a very characteristic dissimilarity between the configuration of Mars and that of the earth. On our planet the seas have greater extent than the con-

tinents. Three-fourths of the surface of our globe is covered with water. The *terra firma* is divided chiefly into three great islands or continents, one extending from east to west, and constituting Europe and Asia; the second, situated to the south of Europe, in shape like a V with rounded angles, is Africa; the third is on the opposite side of the earth, and lies north and south, forming two V's, one above the other. If to these we add the minor continent of Australia, lying to the south of Asia, we have a general idea of the configuration of our globe.

It is different with the surface of Mars, where there is more land than sea, and where the continents, instead of being islands emerging from the liquid element, seem rather to make the oceans mere inland seas—genuine mediterraneans. In Mars there is neither an Atlantic nor a Pacific, and the journey round it might be made dry-shod. Its seas are mediterraneans, with gulfs of various shapes, extending hither and thither in great numbers into the *terra firma*, after the manner of our Red Sea.

FIG. 2.

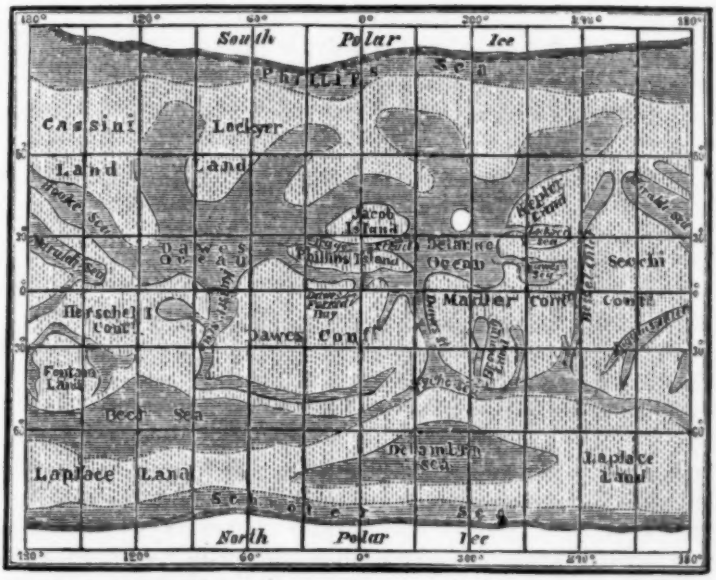



CHART OF THE SURFACE OF MARS, SHOWING THE DISTRIBUTION OF LAND AND WATER.

The second character, which also would make Mars recognizable at a distance, is that the seas lie in the southern hemisphere mostly, occupying but little space in the northern, and that these northern and southern seas are joined together by a thread of water. On the entire surface of Mars there are three such threads of water extending from the south to the north, but, as they are so wide apart, it is but rarely

that more than one of them can be seen at a time. The seas and the straits which connect them constitute a very distinctive character of Mars, and they are generally perceived whenever the telescope is directed upon that planet.

The continents of Mars are tinged of an ochre-red color, and its seas have for us the appearance of blotches of grayish green intensified by the contrast with the color of the continents. The color of the water on Mars is therefore that of terrestrial water. But why is the land there red? It was at one time supposed that this tinge must be owing to the Martial atmosphere. It does not follow that, because our atmosphere is blue, the atmosphere of the other planets must have the same color. Hence it was permissible to suppose that the atmosphere of Mars was red. In that case the poets of that world would sing the praises of that ardent hue, instead of the tender blue of our skies. In place of diamonds blazing in an azure vault, the stars would be for them golden fires flaming in a field of scarlet; the white clouds suspended in this red sky, and the splendors of sunset, would produce effects not less admirable than those which we behold from our own globe.

But the case is otherwise. The coloration of Mars is not owing to its atmosphere; for, although the latter is spread out over the entire planet, neither its seas nor its polar snows assume the red tinge; and Arago, by showing that the rim of the planet's disk is of a less deep tinge than the centre, proved that the color is not due to the atmosphere. If it were, then the rays reflected from the margin to us would be of a deeper red than those reflected from the centre, as having to pass through a greater height of atmosphere. May we attribute to the color of the herbage and plants, which no doubt clothe the plains of Mars, the characteristic hue of that planet, which is noticeable by the naked eye, and which led the ancients to personify it as a warrior? Are the meadows, the forests, and the fields, on Mars, all red? An observer, looking out from the moon, or from Venus, upon our own planet, would see our continents deeply tinged with green. But, in the fall, he would find this tint disappearing at the latitudes where the trees lose their leaves. He would see the fields varying in their hues, and then would come winter, when they would be covered with snow for months. On Mars the red coloration is constant; it is observed at all latitudes, and in winter no less than in summer. It varies only in proportion to the clearness of the atmospheres of Mars and the earth. Still this does not preclude the supposition that the Martial vegetation has its share in producing the red hue of the planet, though it be principally due to the color of the soil. The land cannot be all over bare of vegetation, like the sands of Sahara. It is very probably covered with a vegetation of some kind, and, as the only color we perceive on Mars's *terra firma* is red, we conclude that Martial vegetation is of that color.

We speak of plants on Mars, of the snows at its poles, of its seas, atmosphere, and clouds, as though we had seen them. Are we justified in tracing all these analogies? In fact, we see only blotches of red, green, and white, upon the little disk of the planet; but, is the red *terra firma;* the green, water; or the white, snow? Yes, we are now justified in saying that they are. For two centuries astronomers were in error with regard to spots on the moon, which were taken for seas, whereas they are motionless deserts, desolate regions where no breeze ever stirs. But it is otherwise as regards the spots on Mars.

The *unvarying* aspect of the moon never exhibits the slightest cloud upon its surface, nor do the occultations of stars by its disk reveal even the slightest traces of an atmosphere. Contrariwise, the aspect of Mars is *ever varying.* White spots move about over its disk, very often modifying its apparent configuration. These spots can be nothing else but clouds. The white spots at its poles increase or diminish with the seasons, exactly like the circumpolar ice of earth, which, for an observer on Venus, would have the same aspect and the same variations as the polar spots of Mars have for us. Hence we conclude that these Martial white polar spots are masses of frozen water. Each hemisphere of Mars is harder to observe during its winter than during its summer, being often covered with clouds over its greater part. This would be precisely the aspect of the earth if observed from Venus. But what causes these clouds over Mars? Plainly nothing else but the evaporation of water. As for the ice, that is the same water frozen. But is the water there the same as here? Down to a few years ago, this question remained unanswered, but now it admits of a reply, thanks to the spectroscope, and the observations especially of Mr. Huggins.

The planets reflect the light they receive from the sun; on examining their spectra, we find the solar spectrum as though it had been reflected from a mirror. If we direct the spectroscope on Mars, we get, first of all, an image perfectly identical with that produced by the central star of our system. But, by the employment of more exact methods, Mr. Huggins found, during the last opposition of the planet, that the spectrum of Mars is crossed, in its orange portion, by a group of black lines *coincident with the lines which appear in the solar spectrum at sunset* when the sun's light passes through the denser strata of our atmosphere. Now, are these tell-tale rays produced by our atmosphere? To decide this question, the spectroscope was turned on the moon, which was at the time nearer the horizon than Mars. If the lines in question were produced by our atmosphere, they must have appeared in the lunar as well as in the Martial spectrum, and with greater intensity in the former. Yet they were not to be seen at all in the lunar spectrum; and hence it is plain that they are owing to the atmosphere of Mars.

The atmosphere of that planet, therefore, adds these special char-

acters to those of the solar spectrum, and this proves that the atmosphere of Mars is analogous to that of earth. But what is that atmospheric matter which produces these significant lines? From an examination of their positions, we find that they are not owing to the presence of oxygen, nitrogen, or carbonic acid, but to watery vapor. Therefore, there is *water-vapor in the atmosphere of Mars*, as in that of the earth. The green spots on its globe are seas—expanses of water resembling our seas. The clouds are made up of minute vesicles of water, like our own mists; and the snows consist of water solidified by cold. Furthermore, this water, as revealed by the spectroscope, being of the same chemical composition as terrestrial waters, we know that Mars possesses oxygen and hydrogen.

These important data enable us to form an idea of Martial meteorology, and to recognize therein a reproduction of the meteorological phenomena of our own planet. On Mars, as on earth, the sun is the supreme agent of motion and of life. Heat vaporizes the water of the seas, causing it to ascend into the atmosphere. This vapor assumes visible shape by the same processes which produce clouds here, i. e., by differences of temperature and of saturation. Winds arise in virtue of these same differences of temperature. We can observe the clouds on Mars as they are swept along by air-currents over the seas and continents, and several observers have, so to speak, photographed these meteoric variations.

If we are as yet unable precisely *to see the rain falling* on the plains of Mars, we can at least tell when it is falling, for we can see the clouds dispersing and gathering again. Thus there is on Mars, just as on earth, an atmospheric circulation, and the drop of water which the sun takes from the sea returns thither after it has fallen from the cloud which concealed it. And, although we must sternly resist any tendency to fashion imaginary worlds after the pattern of our own, still Mars presents to us, as in a mirror, such an organic likeness to earth, that it is hard for us not to carry our description a little further.

Thus, then, we behold, in space, millions of miles away, a planet very much like our own, and where all the elements of life exist, as they do here—water, air, heat, light, winds, clouds, rain, streams, valleys, mountains. To complete the resemblance, the seasons there are very much the same as here, the axis of rotation of Mars having an inclination of 27°, while that of the earth is 23°. The Martial day is forty minutes longer than the terrestrial.

In the face of all these facts, can we be content with the conclusions we have so far reached without going further, and considering ulterior consequences? If the same physico-chemical conditions are present on Mars as on earth, why should they not produce the same effects there as here? On earth the smallest drop of water is peopled with myriads of animalcules, and earth and sea are filled with count-

less species of animals and plants; and it is not easy to conceive how, under similar conditions, another planet should be simply a vast and useless desert.—*La Nature.*

## TENNYSON AND BOTANY.

By J. HUTCHISON.

WORDSWORTH, in the supplementary preface contained in the second volume of his works, asserts in the most emphatic way the deplorable ignorance of "the most obvious and important phenomena" of Nature which characterizes the poetical literature of the period intervening between the publication of the "Paradise Lost" and the "Seasons." It is to be feared that his opinion is, to a large extent, justified by the facts of the case. A very cursory examination of the productions of the poets who flourished during the seventy years referred to will suffice to show how little they were affected by the manifold beauty and grandeur of the visible universe everywhere around them. In this respect they contrast unfavorably, not only with their successors of the present century, which might have been expected, but with those of the two preceding centuries as well. The latter, whose works embrace a period dating back a hundred years from Milton, display, generally, a much more accurate acquaintance with the appearances and phenomena of the natural world, and spontaneousness in the expression of it, than the school of Dryden and Pope, who may be regarded as the most conspicuous examples of Wordsworth's strictures. Of Pope, particularly, it might almost be said that, from his writings, it could scarcely be inferred that there was much else in existence than courts, and fashion, and scandal—not much, at all events, that was worth caring for. He excelled in the representation of the modish life of the day—its fine ladies with their patches, its fine gentlemen with their periwigs, and its general artificiality. Of Nature in its endless continuity, and variety, and mysteriousness, which has stirred the hearts of men in every age, and kindled many smaller poets into enthusiasm, he knew and cared little, and the trim alleys and botanical distortions of Versailles, which he has characteristically described, may be taken as typical of his own inspiration on the matter. It may be worth while mentioning, as a pertinent illustration of these comments, that in his poem of "Windsor Forest," with the exception of a semi-patriotic allusion to the oak, in connection with ship-building, there is not a reference to a single forest-tree, not even to any of those famous historical oaks which abound in the locality. Nature and simplicity, in truth, had gone out of fashion, and were not much in vogue again till far on in the century.

Darwin, a mere poetaster compared with the genius of Twickenham, is a well-known instance of the opposite defect—of the absence

of poetic fire rather than of a taste for the delights of the country. His "Botanic Garden" is a dreary, mechanical affair, several degrees worse and more unreadable than Cowley's "Plants," a century earlier. Both are constructed on an altogether erroneous principle. Science is science, and poetry is poetry; and while, as is well illustrated in "The Princess" and "In Memoriam," the scientific spirit may be distinctly present, yet any thing like a formal, didactic attempt at amalgamation is certain to prove a failure.

Although belonging to an earlier date than the sterile period referred to, George Herbert might also be quoted here as a case of poetic talent of a very genuine kind, yet unaccompanied by much perception of natural beauty or picturesqueness. He has sometimes been likened to Keble, a brother churchman and clergyman, but between the two, in their feeling and apprehension of the wonders of creation, the difference is singular and complete. Herbert's strong point was spiritual anatomy. His probing and exposure of the deceits and vanities of the human heart, and his setting forth of the dangers of the world to spirituality of mind, are at once quaint and incisive. But of any love or special knowledge of the physical world there is scarcely a trace.[1] Keble's poetry, on the other hand, quite as unworldly as that of the author of "The Temple," is redolent everywhere of the sights and sounds of Nature. The seasons with their endless changes, the motions of the heavenly bodies, the fragrance of the field, trees, rivers, mountains, and all material things, are assimilated, so to speak, into the very essence of his verse. That very world which to Herbert was only base and utterly indifferent, seemed to Keble, to use his own words, "ennobled and glorified," and awakened in his soul poetical emotions of the highest and purest kind.

It is unnecessary to enter into much detail in order to show how, much more truly than himself, Pope's predecessors, and especially those of the Elizabethan era, were entitled to the designation of poets of Nature. Shakespeare, Spenser, the two Fletchers, Milton, and many others, might be adduced in confirmation. With reference to botany, it is evident that the greatest of the tribe, in his universality of knowledge, flowing over into every region of human research, was well acquainted with the subject in its twofold aspect—trees and flowers. Many beautiful floral descriptions occur in the plays, and although the arboricultural allusions are less frequent, they are sufficiently numerous to justify the belief that his knowledge was both extensive and accurate. Perhaps the most important passage of the kind is where Cranmer, "dilating on a wind of prophecy," portrays, under the figure of a "mountain-cedar," the future glories of the reigns of Elizabeth and her successor.[2] Milton has many striking and appro-

[1] One of his biographers has discovered a solitary verse, on the faith of which he complacently assumes that Herbert "was thoroughly alive to the sweet influences of Nature."

[2] Commentators affirm Ben Jonson to be the author of the lines referred to.

priate images borrowed from trees. His artistic use of the pine as a simile for Satan's spear—

> "to equal which the tallest pine,
> Hewn on Norwegian hills to be the mast
> Of some great ammiral, were but a wand"—

and the comparison of the rebel host to blasted pines, are fine examples of the poetical transmutation of botanical knowledge. Still finer is the exquisite description in "Lycidas" of the vernal flowers strewed on the hearse of his lamented friend. And, not to multiply quotations further, the vale of Vallombrosa has been immortalized forever by three lines in "Paradise Lost."[1]

In later poetry, not of the present century, Shenstone and Cowper were both genuine lovers of Nature, and their works abound with passages relating to rural pleasures and scenery. Cowper, indeed, might be styled *par excellence* the poet of the country. No one ever believed more thoroughly than himself in his own epigrammatic line—

> "God made the country, and man made the town."

The revolution in the poetical taste of the time, afterward consummated by Wordsworth, was mainly initiated by the recluse of Olney. In Shenstone's poems, now, it is to be feared, little read, there are some verses bearing on the subject of this essay which have a curious resemblance to Mr. Tennyson's famous song, "Come into the garden, Maud." We quote eight lines to be found in the piece designated a "Pastoral Ballad, in Four Parts:"

> "From the plains, from the woodlands and groves,
> What strains of wild melody flow!
> How the nightingales warble their loves
> From thickets of roses that blow!
> . . . . . .
> "Then the lily no longer is white;
> Then the rose is deprived of its bloom;
> Then the violets die with despite,
> And the woodbines give up their perfume."

The ring and manner of this are very similar to Mr. Tennyson's composition, and, although the measure is a little different, these verses might be interpolated in the modern song without in the least impairing its harmony, or affecting its verisimilitude.

The most distinguished names in the list of the natural poets of the present century are undoubtedly Sir Walter Scott, Wordsworth, and Mr. Tennyson. Of the two former it may be said, in passing,

[1] "Till on the beach
Of that inflamèd sea he stood, and called
His legions, angel forms, who lay intranced,
Thick as autumnal leaves that strew the brooks
In Vallombrosa."

that they have probably done more than anybody else to foster the modern idea of Nature, and the love of wild and picturesque scenery. Our business, however, is more particularly with Mr. Tennyson, and with the evidences of botanical knowledge to be found in his works, that part of botany, at least, relating to trees. These allusions, we apprehend, are more numerous, and show more insight, and acquaintance with the forms, and processes, and changes characteristic of the inhabitants of the forest, than those of any other modern author. His verse in this respect differs from other descriptive poetry chiefly in this, that his notices are not general appellations or similitudes applicable equally to any or all trees, but are specific, exact, and true only in the particular case. Thomson, for example, in the "Seasons," is, in general, curiously vague in his descriptions. He generalizes constantly, and presents his readers with broad effects sketched *en masse*, instead of individual details. Such phrases as "sylvan glades," "vocal groves," "umbrageous shades," and the like, frequently occur, doing duty in place of more minute representations. Mr. Tennyson, on the other hand (and Sir Walter and Wordsworth may also be included), pursues exactly the contrary method. His descriptions are, nearly always, pictures of particular places instead of fancy sketches, and the distinguishing features are given incidentally in the course of the narrative. Where, again, particular trees are referred to, it is almost invariably with a phrase or an epithet clinching the description as precisely as a paragraph from Evelyn or Loudon. And, as poetry, these casual, accidental bits of descriptive writing are infinitely more effective than any amount of versified disquisition, of the Darwin sort, on the processes of vegetation. Slight, too, though in many cases they are, they indicate a deep appreciation of the results and tendencies of modern science. In what remains of this paper it is proposed, a little in detail, to adduce evidence from Mr. Tennyson's poems in support of the views we have expressed. It will not be necessary to go over the whole field, and we shall therefore select a few of the more important trees, and see to what extent his notices of them are corroborative of these preliminary remarks.

The ash will be the first example, and the reference in the lines quoted below is to the proverbial lateness of this tree in developing its foliage. It forms part of the Prince's song in "The Princess:"

> "Why lingereth she to clothe her heart with love,
> Delaying as the tender ash delays
> To clothe herself, when all the woods are green?"

This is a very striking comparison, happily expressed, and, besides serving its immediate purpose, corrects an erroneous notion, somewhat popular, that sometimes the ash and sometimes the oak is in leaf first. Then, again, in "The Gardener's Daughter," Juliet's eyes and hair are thus described:

"Love, unperceived,
Came, drew your pencil from you, made those eyes
Darker than darkest pansies, and that hair
More black than ash-buds in the front of March;"

a fact which all observers of the phenomena of the spring months will recognize as accurate.

The lime seems a special favorite of Mr. Tennyson, so lovingly and frequently does he use it for illustration. There is much imitative beauty in the well-known lines (also from "The Gardener's Daughter") which form the conclusion of the description of a cathedral city—possibly Peterborough:

"And all about the large lime-feathers low,
The lime a summer home of murmurous wings."

The giving out of branches close to the ground is a noticeable habit of the lime, as it is also, to some extent, of the elm, particularly in Devonshire. The mode of growth and the development of the branches are still further illustrated:

"Not thrice your branching limes have blown
Since I beheld young Laurence dead."

The epithet "branching" refers to another peculiarity—the number and intricacy of the branches in the centre of the tree. On this point Mr. Leo Grindon, a good authority, says: "So dense is the mass, that to climb a full-grown tree is nearly impossible." The frequent use of the lime for avenues and walks, a practice still more prevalent on the Continent, is very pictorially stated:

"and overhead,
The broad ambrosial aisles of lofty lime
Made noise with bees and breeze from end to end."

Its spring-time is photographed in "Maud" in a single sentence, thus:

"A million emeralds break from the ruby-budded lime."

Every student of botany will be able to verify the correctness of this line. The buds are peculiarly red, and the appearance of thousands of them bursting at once is precisely as the poet describes it. Elsewhere, the period immediately preceding the foliation of the tree is sketched with remarkable truthfulness:

"On such a time as goes before the leaf,
When all the wood stands in a mist of green,
And nothing perfect."

The Spanish chestnut, *Castanea*, is not one of Mr. Tennyson's trees; but there are frequent references to the horse-chestnut, *Æsculus*. The three chestnuts in "The Miller's Daughter" will be in the recollection of most readers of his poetry. The appearance of the buds

just before emerging from their green covering, and the time of their development, are registered with minute accuracy:

"But, Alice, what an hour was that,
When, after roving in the woods
('Twas April then), I came and sat
Below the chestnuts, when their buds
Were glistening in the breezy blue!"

"Glistening" is the exact epithet here. The early foliation of the chestnut and elm we find in the exquisite fragment "Sir Launcelot and Queen Guinevere." The lines on the chestnut are very characteristic:

"In curves the yellowing river ran,
And drooping chestnut-buds began
To spread into the perfect fan,
Above the teeming ground."

This, with the similar remark on the elm, corresponds to the order of Nature, and is nowhere better or more beautifully exemplified than in Kensington Gardens every April.

So far as we have been able to discover, there is only a single line devoted to the birch. It is to be found in "Amphion," that singular reproduction, in sylvan form, of the mythological legend. It is interesting to notice, by-the-way, that, in the later editions, the verse in which the birch is mentioned is omitted, and another substituted. As a whole, the latter is doubtless the more musical of the two, but we are sorry to lose the apt and charming characterization of "the lady of the woods." For the curious in Tennysoniana we print both:

"The birch-tree swang her fragrant hair,
The bramble cast her berry,
The gin within the juniper
Began to make him merry."

. . . . . .

"The linden broke her ranks and rent
The woodbine-wreaths that bind her,
And down the middle, buzz! she went
With all her bees behind her."

Of all the poets who have sung the praises of the birch, Coleridge, Keats, and, preëminently Sir Walter Scott, none of them has surpassed the initial line of the first stanza in condensed and subtile expressiveness. Scott's is somewhat similar, although not quite so good:

"Where weeps the birch with silver bark,
And long dishevelled hair."

"Dishevelled," implying disorders and entanglement, does not convey a correct idea of the foliage of the birch. "Swang her fragrant hair" is decidedly better.

The fullness and ripeness of the poet's knowledge of trees are amply

illustrated in those passages of his poems relating to the poplar. This is a tree with which he has been familiar from early childhood, as we gather from the "Ode to Memory," where he fondly recalls—

> "The seven elms, the poplars four,
> That stand beside my father's door."

The famous poplar in "Mariana," which Mr. Read has reproduced in his fine picture of the "Moated Grange," now at South Kensington, is a prominent object in a very striking poem. The locality, it is scarcely necessary to say, is the fen country:

> "About a stone-cast from the wall
> A sluice with blackened waters slept,
> And o'er it many, round and small,
> The clustered marish-mosses crept.
> Hard by a poplar shook alway,
> All silver-green with gnarlèd bark;
> For leagues no other tree did mark
> The level waste, the rounding gray."

As an example of landscape-painting in words, there is nothing more perfect than this in modern literature. We are not aware if the doubt was ever suggested before, but we think it is at least questionable if Mr. Read is right in assuming the particular tree in his poem to be a Lombardy poplar. "Silver-green," a remarkable epithet, is more applicable to the abele, or white poplar, than to the fastigiate Lombardy species, and the sound of the trembling of the leaves is less noticeable in the latter than in most of the other poplars. In other poems this rustling noise is described as "lisping," "hissing," and like the sound of "falling showers," phrases all tolerably approximating to exactness. In "In Memoriam" there is a special reference to this white poplar whose silver-green foliage shows much more white than green in a gale of wind:

> "With blasts that blow the poplar white,
> And lash with storm the streaming pane."

The "quivering," "tremulous" aspen is also mentioned, but Mr. Tennyson is too good a botanist to fall into the popular error of supposing that it is the only tree which has fluttering leaves. Except the Ontario species and one or two others, nearly all the poplars have the same peculiarity, caused, it may not be superfluous to say, by the compression of the leaf-stalk. Very curious it is to notice in the upper branches, while a light wind is overhead, each particular leaf shaking on its own account, while the branch of which it is a part, and the tree itself, are perfectly motionless.

Of the beech the notices are scantier and less specific. Its peculiarly twisted roots, rich autumn tints, smooth bark, and unusual leafiness, are all described, however, more or less poetically. The following verse from "In Memoriam" has a certain pensive sweetness of its own:

"Unwatched, the garden bough shall sway,
The tender blossom flutter down,
Unloved that beech will gather brown,
This maple burn itself away."

The rich autumn tints of the foliage of the maple are here alluded to.

Cedars, cypresses, and yews, all members of the great coniferous family, are prominent objects in Mr. Tennyson's landscapes. In the eighteenth section of "Maud"—beginning,

"I have led her home, my love, my only friend"—

and which contains some passages full of solemn tenderness and beauty, and a splendor of language worthy of Shakespeare himself, occurs the oft-quoted apostrophe addressed to the cedar of Lebanon by Maud's somewhat distempered, though now happy lover:

"Oh, art thou sighing for Lebanon
In the long breeze that streams to thy delicious East,
Sighing for Lebanon,
Dark cedar. . . . . .
. . . . . .

"And over whom thy darkness must have spread
With such delight as theirs of old, thy great
Forefathers of the thornless garden, there
Shadowing the snow-limbed Eve from whom she came.
Here will I lie, while these long branches sway."

The yew, though usually regarded as the emblem of death—

"Cheerless, unsocial plant, that loves to dwell
Midst skulls and coffins, epitaphs and tombs"—

might, in its extreme tenacity and length of days, be a fitter representative of life and endurance. In the second chapter of "In Memoriam" the yew is described in the most masterly manner. These are two of the verses:

"Old Yew, which graspest at the stones
That name the underlying dead,
Thy fibres net the dreamless head,
Thy roots are wrapped about the bones."

"Oh, not for thee the glow, the bloom,
Who changest not in any gale,
Nor branding summer suns avail
To touch thy thousand years of gloom."

The locality, the hue, the prolonged life, and the general unchangeableness of appearance, are all here summarily noticed. The laureate seems, however, to share the popular dislike to this tree, a feeling which Gilpin, in his "Forest Scenery," ridicules as weakness. In "Amphion," yews are called "a dismal coterie;" in "Maud" a "black yew gloomed the stagnant air;" and, in "Love and Death,"

we have the portentous image of the angel of death walking all alone "beneath a yew."

Our limits forbid more than a mere enumerative mention of other well-known trees, whose memory Mr. Tennyson has rendered sweeter to all future generations of tree-lovers. "Immemorial elms," "perky larches and pines," "laburnums, dropping-wells of fire," elders, hollies, "the pillared dusk of sounding sycamores," "dry-tongued laurels," "slender acacias"—all these and many others are to be found within the four corners of his poems. One only remains, the oak—"sole king of forests all;" and, as Mr. Tennyson has celebrated the praises of the monarch of the woods at great length in the "Talking Oak," we shall add a few words on that charming composition by way of conclusion.

As is well known, the poem takes the form of a colloquy between an ancient oak, which formed a meeting-place for two lovers, and the young gentleman in the case. He comes to question the tree about his lady-love, who had visited the hallowed spot in his absence. And Landor himself, in his happiest vein, never conceived a more exquisite imaginary conversation. Here, in sportive phrase and bantering talk, is the whole philosophy of forest-life set forth with a poetic felicity, saucy humor, and scientific precision of language, each admirable of its kind. The poem is literally a love-idyl and botanic treatise combined, and never, surely, were lovers and science—January and May, might one say—so delightfully harmonized, conveying, too, to those who have eyes to see and hearts to understand, glimpses of a spiritual interpretation of Nature, undreamt of by Pope and his school. Thus pleasantly does the old oak of "Sumner Chace" discourse to Walter of Olivia's charms; and the reader will not fail to notice the skillful way in which the poet's practical acquaintance with trees is turned to account:

> "I swear (and else may insects prick
> Each leaf into a gall)
> This girl, for whom your heart is sick,
> Is three times worth them all;"

and then, with a warmth of praise unusual and almost improper in such a venerable inhabitant of the forest, he continues:

> "Her kisses were so close and kind,
> That, trust me on my word,
> Hard wood I am, and wrinkled rind,
> But yet my sap was stirred:
>
> "And even into my inmost ring
> A pleasure I discerned,
> Like those blind motions of the spring,
> That show the year is turned."

Farther on, the not ungrateful lover invokes all atmospheric and

other good influences on his partner in the dialogue, who has proved so communicative a companion:

"O rock upon thy towery top
All throats that gurgle sweet!
All starry culmination drop
Balm-dews to bathe thy feet!
. . . . . .
"Nor ever lightning char thy grain,
But, rolling as in sleep,
Low thunders bring the mellow rain,
That makes thee broad and deep!"

These, it will be admitted, are very melodious strains. Seldom has the imagery of the woods been used with more appropriateness and effect than in this poem, and its poetic excellence is rivaled by its accuracy. No one but an accomplished practical botanist could have written it. And throughout the poem, light and airy in tone as it is, there is distinctly perceptible the scientific element—the sense of the forces of Nature acting according to law, which, as we have already said, pervades like a subtile essence much of Mr. Tennyson's poetry. But enough has probably been said to justify the title of this article.—*St. Paul's Magazine.*

## "WATER TURNED TO BLOOD."

FROM THE FRENCH OF DR. N. JOLY.

FROM the remotest antiquity the red color sometimes observed in water appears to have attracted attention. In all ages there have been stories of rains of blood, and of rivers changed to blood, and these phenomena have given rise to the most ludicrous explanations, and to the most ridiculous apprehensions. In Exodus (vii., 20, 21), we read: "All the waters that were in the river were turned to blood. And there was blood throughout all the land of Egypt." Homer speaks of the dews of blood which preceded the Trojan War, and those which foreboded the death of Sarpedon, king of the Lycians. Pliny in his "Natural History" (book ii., c. xxxvi.) tells of a rain of milk and blood which fell at Rome in the consulship of M. Acilius and C. Portius. Finally, the historian Livy mentions a rain of blood which fell in the Forum Boarium. In times much nearer to our own, phenomena of this kind have been observed at various points in Europe, producing ridiculous alarms, and even leading to actual seditions.

The cause, or causes rather, of these so-called rains of blood are now well understood. Every one knows that they are to be attributed

either to mineral particles diffused through the air strata which are traversed by the rain, or to the dejections of certain moths in their last metamorphosis, or to the remains of infusoria carried up by the

Fig. 1.

Red Water of the Salt-Marshes, taken from the surface.

Fig. 2.

The same after it has been allowed to rest. (The infusoria have risen to the surface.)

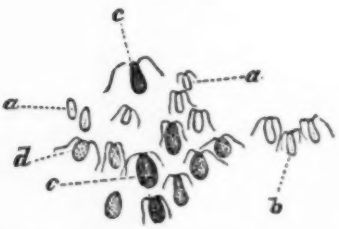
winds. But the ignorant multitude continue still to believe in rains of blood, and bow down blindly before so-called miracles which have no existence save in the wild fancies of those who regard them as articles of faith.

We are not concerned now with these errors and superstitions, on which modern science has pronounced its verdict; we propose rather to consider some well-attested facts, the causes of which leave no room for doubt or ambiguity. It is now ascertained beyond question that, where fresh water wears a peculiar tinge, this coloring is due to the presence of infusoria (*Euglena viridis*, *E. sanguinea*, *Astasia hæmatodes*), or to microscopic vegetation (*Oscillatoria rubescens*, *Sphæroplea annulina*), or to minute entomostraca (*Daphnia pulex*, *Cyclops quadricornis*).

The waters of the sea may also be tinged in a similar way. Thus, in 1820, Scoresby found that the blue or green tinge of the Greenland Sea was caused by an animalcule allied to the medusæ. Of these he counted 64 in a cubic inch; this would be in a cubic foot 110,392, and 23,888,000,000,000 in a cubic mile. According to Arago, the long and sharply-defined streaks of green in the polar seas include myriads of medusæ, whose yellow color, added to the blue of the water, produces green. Off Cape Palmas, on the Guinea coast, Captain Tuckey's ship appeared to be sailing through a milky sea. The cause of the phenomenon was the multitude of animals floating at the surface, and masking the natural tint of the water. The carmine-red streaks which various navigators have sailed through on the high-seas are produced in the

same way. In 1844 Messrs. Turrel and Freycinet saw the Atlantic Ocean, off the coast of Portugal, of a deep-red color, owing to the presence of a microscopic plant of the genus *Protococcus* (*P. Atlanticus*). This color was diffused over an area of no less than five square miles. M. Montagne, who has described the alga which produced this

FIG. 3.




MONAS DUNALII MAGNIFIED.—*a*. Very young individuals, colorless. *b*. Individuals not yet full grown, colored green. *c*. Adults very deep red. *d*. Adults of lighter red.

FIG. 4.

MONAS DUNALII, dead, and of globular shape.

phenomenon, closes his memoir in these words: "When we reflect that, in order to cover one square millimetre (0.03937 inch), we must have 40,000 individuals of this microscopic alga, we are filled with amazement on comparing the immensity of such a phenomenon with the minuteness of the cause which produces it."

As for the waters of the Red Sea, the periodic reddening which distinguishes them is caused by the presence of a confervoid alga which naturalists have called *Trichodesmium erythræum*. Finally, Pallas tells of a lake in Russia, called Malinovoé-Ozéro, or Raspberry Lake, because its briny water and the salt made from it are red, and have the odor of violets.

The coloration of the Mediterranean salt-marshes, a phenomenon long known to the salt-makers of Languedoc, but first studied by *savants* in 1836, and by me in 1839, has also been explained in various ways more or less near the truth. Messrs. Audouin, Dumas, and Payen, of the Institute, have attributed it to the *Artemia salina*, a minute branchiopod crustacean, which in fact swarms in the *partennements*,[1] where the saltness of the water is far below the degree of saturation requisite for the precipitation of salt crystals, but is of much rarer occurrence where the water, being very highly concentrated, assumes at times a blood-red color. Messrs. A. de Saint-Hilaire and Turpin have supposed the real cause of this strange coloration to be certain microscopic plants, of very simple organization, which they call *Protococcus sanguineus* and *Hæmatococcus kermesinus*. This, too, was the opinion of M. F. Dunal, who had studied the rubefaction of

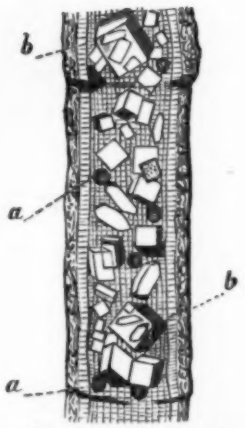
[1] The *sauniers* (salt-makers) of Languedoc give the names of *tables*, *partennements*, and *pièces maîtresses* to the various compartments into which the sea-water is passed as it arrives at different degrees of salinity.

the water of our salt-marshes before St.-Hilaire and Turpin. As I was at that time employed in teaching Natural History in the Royal College of Montpellier, where I had among my pupils several youths who have since become distinguished masters themselves (Louis Figuier, Amédée Courty, and Henri Marès, for instance), I too had a desire to study the curious phenomenon of the reddening of water, and to this end I visited the salt-works of Villeneuve, two or three miles distant from Montpellier. The water there was then of a very decided red color. I collected on the spot some samples of the water which looked most like blood, and also of water which, being less briny than this, was also of a fainter red color. Under the microscope the water collected in the various compartments exhibited myriads of minute creatures, with oval or oblong bodies, often compressed in the middle, but sometimes cylindrical. Very young individuals were colorless, those a little older were greenish, and the adult were of a deep red. The mouth had the form of a conical prolongation, and was retractile; they were eyeless, and the stomach and anus could not be clearly made out.

FIG. 5.

DEAD MONADS, colorless.

FIG. 6.

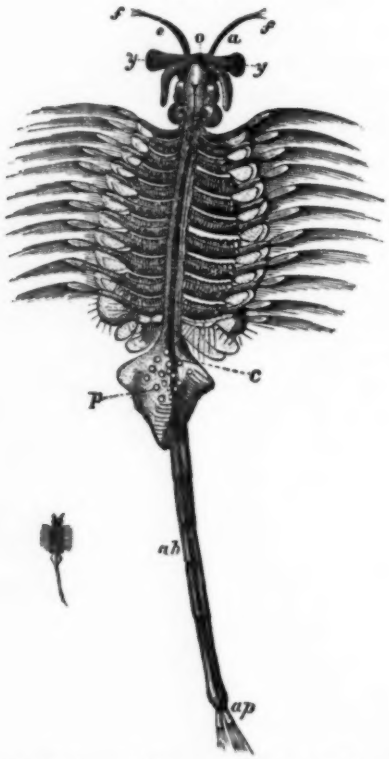



PART OF THE DIGESTIVE TUBE OF ARTEMIA SALINA, in which are seen (*a*, *a*) dead but not digested monads, and (*b*, *b*) cubical salt-crystals.

With a high-power microscope I was able to see in the anterior part of these supposed *protococci* two long, flagelliform, and perfectly transparent processes which they kept in rapid motion, and by means of which they swam about in the drop of liquid spread out on the slide of my instrument. There was no longer room for doubt. The *protococci* and *hæmatococci* of Messrs. Dunal, St.-Hilaire, and Turpin, were animals—true *monads*, and I gave them the name of *Monas Dunalii*, in honor of my preceptor, Prof. Dunal. He was the first to suspect the true cause of the red color of the Mediterranean salt-marshes; but he had only an indistinct insight into the matter. He examined the

animalcules only after they were dead, that is, at the moment when they had become globular and motionless, like *protococci;* and his specimens were dead, because he had filled his vials up to the brim with the water, and then sealed them hermetically. But these little animals must, above all things, have free respiration. Accumulated in immense numbers in a very small quantity of water, with the outer air entirely excluded, they all died while being carried from Villeneuve to Montpellier. They were then taken for *protococci*, being motionless and globular. I took precautions against committing this mistake, by only half filling my specimen-tubes, and, better still, by examining the water of the salines on the spot.

FIG. 7.




ARTEMIA SALINA (adult) natural size, and highly magnified. *o*. Median eye. *y, y*. Pedunculate eyes. *a, e*. Antennæ. *p*. Incubatory pouch with eggs. *ab*. Abdomen. *ap*. Tail-shaped appendages. *c*. Digestive tube.

It is a remarkable fact in the history of the *Monas Dunalii* that, like the *Protococcus nivalis*, which gives to the snow of the polar regions now a green tinge, anon a red, this animalcule presents, when young, a green tinge, which changes later to brick-red, and then to blood-red.

The degree of concentration of the water has a marked influence on them. On the 1st October, 1839, after the driest summer on record, the liquid in the *tables* indicated 25° salinity in Baumé's areometer, and it was of so deep a color as to stain a corner of my pocket-handkerchief a blood-red. On October 28th, after twenty-eight days of steady rain, the water in the *pièces maîtresses*, instead of presenting a purple color, as on the first day of the month, resembled blood with a very large amount of serum, and the monads in it were less numerous, and of a lighter red, although the water was still of 20° salinity.

Finally, we must not omit to state that the monads are very sensitive to light, which they seek with a certain degree of avidity. This may be easily seen by putting a number of these infusoria into a flask two-thirds filled with sea-water. Soon they will be seen to rise to the surface of the liquid, and to crowd together on the side where the light is strongest. If the flask be turned about so as to bring them on the darker side, they soon take their former position again. We must also observe that these animalcules sometimes go down to the bottom of the *tables*, and then the coloration of the surface grows fainter, or entirely disappears.

From all this it follows that the red color of the Mediterranean salt-marshes is caused by the *Monas Dunalii;* but is that animalcule the only cause of the phenomenon? Has not the *Artemia salina* of Audouin, Dumas, and Payen, also something to do with it? This problem was soon solved. We have first to bear in mind that these little crustaceans are found in far greater numbers in brackish water than in water at its maximum point of concentration, and that in the latter case, indeed, they occur so rarely that their presence may be regarded as in some sort merely accidental. In water of this kind, the *artemia* appears to be sickly; it evidently languishes in the over-dense medium; it swims about with difficulty, always keeping at the surface. It is more or less of a red color along the line of its digestive canal; but this coloration is a secondary thing, and is owing to the monads it has swallowed in water. The latter deposits in their intestine salt-crystals, which may be seen through their transparent envelope, mingled with monads in a state of partial or total digestion.

Far, then, from being the cause of the purple tint of salt-water in its last stage of concentration, the artemia is indebted for its accidental coloring to the *Monades Dunalii* it takes into its digestive canal, or which settle among the filaments of its branchial feet. This I have demonstrated by keeping colorless artemiæ for a while in water tinged by red monads, or simply by carmine, and so giving them a red color.

But, though the artemia has nothing to do with the coloration of water, it is, nevertheless, a subject of wonder and study for the physiologist. Like several other animals belonging to the great sub-kingdom *Articulata* (psyche, bee, silk-worm moth), our crustaceans possess the singular privilege of reproducing themselves without being sub-

jected to the general law of sexual union. Among several thousand artemiæ studied by me, I have not found a single well-defined male individual. The distinguished Genevan naturalist, Carl Vogt, said, the other day, that he had had the like experience. Hence we may conclude that the artemia of our salt-marshes perpetuates its kind by means of virgin females, whose eggs, although deprived of seminal impregnation, are developed in an incubatory sac situated at the base of the maternal abdomen. These produce young artemiæ, which have to undergo amazing metamorphoses before they arrive at a complete resemblance to their parent. The name of parthenogenesis has been bestowed on this singular mode of reproduction by virgin females, independently of commerce with males; oftentimes, the latter do not exist at all, or at least are as yet unknown. In conclusion, we would remark that the eggs of our virgin artemia produce only females, while the unfecundated eggs of the queen-bee produce males, and males only.—*La Nature.*

## THE REQUIREMENTS OF SCIENTIFIC EDUCATION.[1]

By Prof. R. W. RAYMOND.

THERE is danger that, in our new-born zeal for scientific education, we may sacrifice the interests of a truly liberal culture, producing, as I have said, a generation of specialists, incapable of appreciating the departments of human thought which lie outside their own, or even of rising within their own departments to broad and comprehensive views. We must not use the microscope till we spoil the eyes. We must not overtrain the investigator until he becomes less than a full man. The chemists, geologists, and engineers, must not cease to be intelligent and active citizens. It may be demonstrated that such a mistaken neglect of studies outside the range of a chosen profession cripples activity and impairs success even in that profession. It is one result of the brotherhood of knowledge that no man, whether employed in the original investigation of Nature, or in the application of natural laws to practical ends, can advance successfully without perpetual communication of his thoughts to others, and the reception of their suggestions and experiences in return. Hence the mastery of language, which was the first condition of civilization, remains the essential condition of progress. The power to comprehend statements, logical arguments, and demonstrations, and to make such statements as may be comprehended by others, and will carry weight and influence in the very perfection of their form, is a vitally important part

[1] Extract from the Inaugural Address at the dedication of Pardee Hall, of Lafayette College, Easton, Pa., by Rossiter W. Raymond, President of the American Institute of Mining Engineers.

of the preparation of every young man for his life's career. His success, aside from his moral qualities, will be in direct proportion to his influence over other men; and this influence, again, will be in part proportional to his command of the means by which the minds of men are moved, mainly, language. Under this term we may include a knowledge of the methods of practical reasoning, and if this knowledge is best obtained by scholastic study of logic, then logic must be studied. If Latin and Greek are necessary, then they must be studied. For us, one thing is necessary—a thorough mastery of the English tongue—and this alone has been made to yield, in Lafayette College, a mental discipline not inferior to that of the classics.

But influence is not due to language alone. Behind this vehicle of thought there must be fullness and variety of thought itself. Those fruitful analogies, felicitous illustrations, graceful associations, which come, and come alone, through wide acquaintance with human life and literature, are so many elements of power, and, without this broad basis of a common ground from which to move the minds of others, the student of a special science, though possessed of the lever of Archimedes that would move the world, has no place whereon to stand.

In accordance with these principles, the object of the system of college education in America has always been development and discipline of character, and the broad preparation of the student for his subsequent special or professional pursuits. Our colleges may not have succeeded in realizing this ideal, nevertheless this has been their ideal; and it is the right one, as much to-day as ever. Whatever changes are required in our institutions of learning, to adapt them to the necessities of the modern era, must be changes in accordance with this principle—changes of means, not of ends, so far as colleges are concerned.

That changes are required is admitted on all hands. It is admitted that the physical sciences should be introduced to primary and preparatory schools; that they should be taught for the double purpose of mental discipline and of mental acquirement in the class-rooms of our colleges; that in teaching them the scientific, inductive, experimental, instead of the dogmatic, method should be pursued; and, finally, that either connected with our colleges, or standing outside of them, schools of thorough scientific and technical special training are imperatively required. It is to inaugurate the wider activity of such a school that we are met here to-day, and I shall say a few words concerning the relation of this school to Lafayette College, on the one hand, and to technical education and the needs of the present time in technical departments on the other hand.

While we trust that in time to come scientific investigation will be promoted in no mean degree by this school and its graduates, it must be confessed that at the present time its object is chiefly the preparation of young men for practical pursuits involving the applications of

science. Nor can it be fairly said that this department is inferior in dignity to the pursuit of abstract science, so called. It is out of the ranks of the practical workers that those peculiarly gifted in scientific investigation are likely to arise; and it is in the ranks of practical workers that they must look, chiefly, for appreciation and support. It is no derogation from the value of a discovery of truth, to say that it can be made useful to man; and, hence, there is no inferiority in the position of those who make it useful to man.

Indeed, that which the whole world chiefly needs to-day, and our country not less than any other, is the application of scientific truths and principles already known to the affairs, and labors, and problems, of daily life. We might even afford to pause in our career of fresh discoveries, to consolidate the progress and utilize the results already obtained. But the alternative is not presented; it is not necessary or best that any part of the intellectual activity of the age should pause; the advance of science itself assists, and is assisted by, the applications of science.

We need a scientific in the place of a barbarous or scholastic architecture; a scientific in the place of a traditional agriculture; a scientific in the place of an empirical engineering; we need more machinery, more economical applicatians of power, more effective processes of metallurgy and manufacture, more exact knowledge, in all these particulars, of our own condition and necessities, and of the degree in which these can be supplied by experience already attained abroad. Lesoinne, a distinguished French writer, defines metallurgy as "the art of making money in the treatment of metals." This definition may be applied to almost all occupations of life. The practical art of each is not only to achieve certain results, but to do so profitably, to make money in doing so; that is to say, to increase the value of the raw materials, whether wood, or cotton, or ores, or time, or ideas, by the use we make of them, and the transformation to which we submit them, so as thereby to really elevate the condition of humanity: to leave the world better than we found it. This is, in its last analysis, the meaning of honestly making money. Men are put into this world with limited powers and with limited time to provide for their own sustenance and comfort, and to improve their condition. A certain portion of these powers and this time is required for the support of life in a greater or less degree of comfort, and with more or less multiplied means and avenues of enjoyment, activity, and influence. Whatever their labor produces more than this, is represented by wealth, and for purposes of exchange by money. To make money honestly, is to do something for other men better or cheaper than they can do it for themselves; to save time and labor for them; in a word, to elevate their condition. It is in this sense, greatly as we Americans are supposed to be devoted to making money, that we need to learn how to make more money; how to make our labor more fruitful; how

to assail more successfully with our few hands the natural obstacles and the natural resources of a mighty continent; how to build up on the area of that continent a prosperous nation, united in varied, fruitful, and harmonious industries, glowing with patriotism and inspired by religion.

In this work we need specially the basis of a more thorough technical institution, applying principles of science to the material and economical problems involved. This education is necessary to supply the directing forces for the great agricultural, manufacturing, and engineering improvements of the country. It is also needed as a solvent and remedy for the antagonism between labor and capital. The true protection of labor will be found in its higher education, and in opening to the individual laborer for himself and for his children, by means of that education, a prospect of indefinite improvement and advancement.

In the realm of metallurgical and engineering operations the difference between theoretical and practical training is, perhaps, still more striking. The student of chemistry in the laboratory cannot be made acquainted with many of the conditions which obtain in chemical and metallurgical operations upon a larger scale. All the chemists of the world failed to comprehend or to describe correctly the apparently simple reactions involved in the manufacture of pig-iron, until, by the genius and enterprise of such men as Bell, Tanner, and Akerman, the blast-furnace itself, in the conditions of actual practice, was penetrated and minutely studied. Moreover, in all the experimental inquiries of the laboratory the question of economy plays no part. It is the art of separating and combining substances which the student follows there, not the art of making money. That education of judgment and decision, of choice of means for ends which the exigencies of daily practice give, cannot be imparted in the school.

In mechanical engineering the same principle is illustrated. The highest department in this art is that of construction, and in this department the highest function is the designing of machinery. Now, the most perfect knowledge of the theory of a machine and its mathematical relations, of the strength of materials, or the economical use of power, will not suffice to qualify a man to design a machine or a system of machines, for the reason that in this work an element must be considered not at all included in theoretical knowledge, namely, the element of economy in the manufacture, as well as in the operation of the machine. A machine, any part of which requires for its manufacture a tool (such, for instance, as a peculiar lathe) which is not already possessed by the manufacturer, and which, after the construction of this one part, would not be necessary or useful for other work —such a machine could not be profitably built. In other words, machines must be so designed, in a large majority of cases, as not to necessitate the construction of other machines to make them; and the

planning of machinery, so that it shall be at once economical and durable in operation, and simple and cheap in construction, is not merely an important incidental duty, it is absolutely the chief and most difficult duty of the mechanical engineer.

## PREPARATIONS FOR THE COMING TRANSIT OF VENUS.

THE nature of a transit of one of the inferior planets (Mercury or Venus) is well understood, and the phenomena attending such a transit have been thoroughly discussed, and fully described in many places. The importance of the observation of these transits, and the general character of the results expected from the expeditions sent out to observe them, are probably understood by all, but it is thought that a brief account of the means that are to be employed to accomplish the desired end will be of interest.

The records of the plans which have been formed, and of the preparations which have been made by the different governments of the world and by private individuals, are, unfortunately for the general public, published only in proceedings of scientific societies, or in many cases they exist only in manuscript. When the expeditions return home after the observations are made, in astronomical Europe and America will resound the busy hum of preparation, and from the beginning of 1875 the reader of astronomical items will be sated.

At first will come a series of preliminary reports as the parties come in; then we shall have the final reports, giving numbers, data, descriptions of instruments, and the observations made at the transit, the longitudes and latitudes of the various stations, and, in short, every result which the practical astronomer will have derived.

These final reports will be eagerly looked forward to, for upon them depends the constant of solar parallax, and from them will be deduced the definitive result of all the astronomical work done on the globe on that day.

We know already that the final outcome of all these vast preparations which we are going to describe will be a number very near to 8″.848.

The whole world is united in an effort to know exactly how to change this; whether to write it greater or less. But the results of these expeditions, if they are successful (and we can hardly fail of success), will be, not simply the establishing of the earth's distance from the sun on a certain basis, but much more.

So many expeditions of trained scientific observers will bring back with them data only second in importance to the main object of their

journeys. The latitude and longitude of many of the almost unknown islands of both oceans will be established with a certainty as great as the corresponding coördinates of most seaports on our own Atlantic coast. Observations for magnetic constants will be made at places widely separated, and much will be learned in this way. The line of Russian stations, and the American station in Siberia, will be connected by telegraphic wires to St. Petersburg, and possibly the stations in the Indian Ocean may likewise be joined with New York or Washington, so that independent longitude determinations by telegraph may be extended over seven-eighths of the globe.

Americans should not forget that our own Coast Survey has made three independent determinations of transatlantic longitude in the years 1867, 1870, and 1873, nor should they forget the wonderful agreement of the results obtained over three different cables, by different observers at different times. This agreement is so marvelous (considering the independence of the determinations), that the results are here quoted:

*Longitude of Harvard College Observatory, west of Greenwich Observatory.*

| | | | |
|---|---|---|---|
| Campaign of 1867 | 4ʰ | 44ᵐ | 31ˢ·00 |
| Campaign of 1870 | 4 | 44 | 31.05 |
| Campaign of 1873 | 4 | 44 | 30.99 |
| Mean | 4 | 44 | 31.01 |

It must be remembered also that, incidentally as it were, the relative longitude of Paris and Greenwich Observatories was found: so that it is to American astronomers, working by a method of American invention, that the exact value of so important a coördinate is due.

Americans will have reason to be proud if equally exact determinations can be extended by them from the Indian Ocean to New York, and from Siberia to Greenwich.

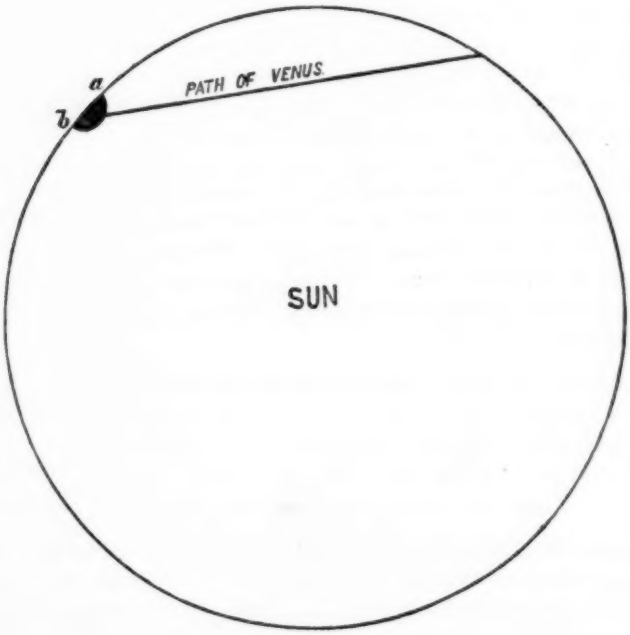
These are only some of the incidental advantages which it may be hoped will be gained by the various expeditions for which the different governments have provided.

There are various ways in which the observation of the transit of Venus may be made, and, in order to describe the instruments, and the preparations which are making, it will be necessary to refer to these briefly:

1. There is *the method of contacts*, which consists in determining the time at which the limb or edge of Venus's disk is tangent to the limb of the sun. To make this observation, a small equatorial telescope is needed, provided with suitable colored glasses to protect the observer's eye, and with the usual appurtenances.

2. The *micrometric method*, which consists in measuring the distance apart of the bright horns of that part of the edge of the sun which Venus partly obscures as she is moving on or off. As Venus has a sensible diameter (about one minute of arc), it will take a sen-

sible time for her disk to move from *first contact* (when her disk just touches the disk of the sun *exteriorly*) to *second contact* (when her disk is tangent *interiorly* to the sun's), and during this time the appearance of the two disks will be as in the figure:




This figure shows Venus coming on to the sun's disk, and it shows the two cusps at *a* and *b*. It will be easily seen that, if we know the length of the line *a b*, and the time at which it has this length, we can calculate the time of contact from these data. So that a number of measures of the cusps is the same as *a number* of first contacts. The reverse phenomenon occurs when Venus passes off the sun's disk.

To measure these distances, the equatorials must be provided with filar micrometers, i. e., with a contrivance by means of which two spider-lines in the focus of the telescope may be moved toward or away from each other. One of these lines is to be placed at *a*, and the other at *b*; the time is to be noted, and the number of turns and parts of a turn of the screw which moves the lines is to be noted from the head of the screw, which is finely divided.

3. The *photographic method.* This consists in photographing the planet Venus on the disk of the sun, and noting the time of each photograph. The negatives are carefully preserved, and are measured subsequently by a fine measuring engine. It will be seen that this method is like the preceding, except that the measuring may be done

at leisure, and without the hurry and anxiety which attach to any observation of this nature.

This method requires apparatus of a special kind. The American plan is to throw the image of the sun, with the planet on its disk, into a stationary photographic telescope where the negative is taken. This is taken out, and at once developed by the photographers, into whose dark room the telescope penetrates. This method is due to Prof. Winlock, of Harvard College Observatory. The other method consists in making the photographic telescope follow the sun in its motion by means of clock-work, and in taking the negatives in the same way. The dark room, however, is some distance off, and it appears that too much dependence must be placed on the steadiness of the clock-work motion.

4. The *heliometric method.* This consists in measuring the cusps with a heliometer, which is merely a large telescope which has two object-glasses (or one object-glass cut into halves by a diametral cut) which slide past each other. Each half produces a complete image, and, by means of an observation of a tangency of images, the distance of the cusps may be had.

5. The *spectroscopic method.* In brief, we may explain this as follows: It is known that there is a thin layer of atmosphere near the sun's limb where bright lines may be seen with a powerful spectroscope, while on either side of this layer dark lines only are seen. As Venus advances, the interposition of her dark body will cut off this layer, and the instant of disappearance of the last vestige of any one of these bright lines will be truly the instant of first contact.

The ordinary method of observing first contact is open to grave uncertainties (on account of the different sensitiveness of the eyes of various observers, and for other reasons), and it is hoped that this method, as beautiful in theory as it will be difficult and delicate in practice, will obviate all these objections.

It is to be expected that the astronomers of the different nations will adopt different plans of observations, in accordance with the peculiar traditions of each school.

The Germans and Russians, among whom the use of heliometers has been hitherto confined, will (with a single exception) alone use them on the approaching transit.

The German Government will send one of these instruments to the Kerguelen Islands, or to Macdonald Island, one to the Auckland Islands, one to the Mauritius, and one to China (Chefoo). Lord Lindsay, of England (the one exception spoken of), also takes a heliometer with his very completely-equipped private expedition to the Mauritius.

Three of the twenty-seven Russian stations in Russia, Siberia, China, and Japan, will be provided with heliometers; at three, likewise, will the photo-heliograph be used, while the remainder of the stations will be devoted to the ordinary contact observations and to measures of cusps.

At all the American stations the photo-heliograph, the contact method, and the method of cusps, will be used. The American stations will be eight in number. These will be principally in the southern latitudes, in the Indian and Pacific Oceans, except one in Siberia, and, perhaps, a photographic station in the Sandwich Islands.

Stations in Japan and China will be established also by the Americans.

Most of the English parties are to be in northern stations, though the Challenger exploring expedition is instructed to examine eligible stations in the South Pacific. Of the stations of French observers little is definitely known, although they will occupy a few posts.

Each party must be provided with instruments to observe the actual transit, and it must further have the means of determining accurately *time*, *longitude*, and *latitude*.

Of these *quæsitæ*, the latitude and the local time are most easily determined. Portable transit-instruments will suffice for the first determination, and for the second there are various adequate means.

The American parties are each to be provided with a small portable transit-instrument and zenith-telescope combined, which instruments are now making by Stackpole, of New York.

These are intended to be of the simplest possible construction and of the greatest attainable stability, and they combine several advantages. In accordance with a suggestion first proposed by Steinheil, of Munich, the tube proper of the telescope will be reduced to one-half of the usual length. A prism will be placed at the end of the tube opposite the object-glass, by which the rays which enter the telescope will be turned at right angles through the perforated axis of the pivots of the instrument, thus utilizing the necessary length of this axis by making it an integral part of the telescope.

The observer will thus occupy one position, no matter to what part of the meridian his telescope is pointed, which is, in itself, a great advantage, on the score of convenience. This also will doubtless conduce to a constant personal equation, as it has been shown by the director of the Albany Observatory, and others, that personal equations vary with the altitude of the observed star.

These instruments are provided with fine spirit-levels and with micrometers, which fit them to be used as zenith-telescopes, and thus to determine two of the three important *quæsitæ*.

The parties of other nations will use similar methods for this purpose. The coördinate which is most difficult of exact determination is the longitude, and the problem of its determination will be attacked in various ways.

The English parties, true to the traditions of Greenwich, are to be provided with portable altitude and azimuth instruments with which to observe moon transits, both in the meridian and out of it. A long series of such moon-culminations was observed between Harvard Col-

lege Observatory and Greenwich some years ago, and it is now known that the result obtained was greatly in error. Indeed, Prof. Peirce, in his discussion of the series of observations, came to the conclusion that it was impossible to derive the longitude of a place by this means, *certainly*, within one second of time.

The Americans and Russians intend to depend on the occultations of small stars by the moon.

Occultations are much more likely to be free from systematic errors than the moon-culminations, and, if they can be observed throughout a lunation, a compensation of errors will obtain.

The Russians intend to mask their stations of observation, and subsequently to connect by telegraph St. Petersburg with the most important of them. The transportation of chronometers to and fro between the stations whose longitude is thus determined and the minor ones will assure the longitude of the latter.

The American parties in the southern seas will be transported to their various stations in a ship-of-war which will touch at the different islands and leave the parties, and which will make chronometric expeditions between the various stations. Besides this, all existing telegraph-lines will be utilized. As each of the parties of each nation is to be led by some astronomer of eminence, it is certain that no means will be neglected to make the preliminary results of the greatest attainable accuracy.

The various assistants are now in training at Greenwich, Poltava, and Washington, with the very instruments which they will use on the expeditions.

At Washington and Poltava an apparatus for the representation of the transit is in use. A disk representing Venus is caused to travel over an illuminated space which is representative of the sun, and the circumstances of the transit are then observed.

In this way it is hoped to obtain an idea of the personal error of each observer in watching contacts, so that, in reducing the observations of the transit, all personality may be eliminated.

Most of the American parties will start in the spring of 1874, and proceed in the most expeditious way to their stations. They must take with them *every thing* which they can need during their stay, for in most of the stations there is no supply of any kind to draw upon.

We can hardly realize the absolute necessity of being provided with every thing that *may be* needed on such an expedition: but let us conceive the feelings of an astronomer on a desert island with no screw-driver, or with no ink, or matches, or soap!

There is no repairing a blunder of outfitting in these cases, and the greatest care has to be exercised in providing for all contingencies.

Arrived at its station the party will put up its observatory, a little wooden or canvas hut which has been brought from America, for no

wood grows on *this* island. The instruments must next be mounted, and all gotten in readiness for work.

The astronomer and his assistant set up the transit, the small equatorial (five inches' aperture, and about seven feet long), and the clock, and provide safe places for their chronograph and chronometers. Suppose a chronometer-spring breaks now: there is no help nearer than New York. The two photographers put up their hut and prepare for work. From this time until the time of the transit, *all* is work.

Every day the methods which will be adopted on the important day are rehearsed. Each one does the very thing which he will do, takes the very steps which he must then take, and turns the very same micrometer-screws just as he will turn them in December. This is repeated until every one is sick of it, and, from a man, each becomes a machine.

During the nights the chief astronomer is looking for occultations, or taking differential measures between the moon's limb and a star, while the assistant is determining time and latitude. Sometimes their work is interchanged, to eliminate any personal peculiarities of observing. When the final day comes, they should have their latitude and longitude thoroughly well known, and their clocks and chronometers rated perfectly. The photographers, too, should know the exact strength of both, the precise time of exposure, and the right developer to make the best possible negative of the sun.

When the time of transit actually comes, the chief will be at the equatorial, and will observe the first contact, and record the time on his chronograph, and at once commence measures of the distance of cusps. The assistant astronomer will see that the heliostat which is to throw the image of the sun into the stationary photographic telescope does this properly; and within the dark room the two photographers must be taking negatives as rapidly as possible.

This continues during the transit from first to second contacts; afterward the photographs succeed each other, but not so rapidly, and finally, the last contact is marked. It is all over now, and there is nothing to do but to write down at once all notes which are to be used in the report, and to prepare for a journey home.

Six or eight months on a rocky island, vast expense, and much trouble and discomfort: but *le jeu vaut la chandelle.* The moral of it is, that Science expects every man to do his duty. Let us hope that Science will not be disappointed.

# THE PRIMARY CONCEPTS OF MODERN PHYSICAL SCIENCE.

By J. B. STALLO.

## III.—*The Assumption of the Essential Solidity of Matter.*

IT cannot have escaped the notice of the attentive reader of the passage quoted in my last paper from Prof. Tyndall's lecture on "The Use of the Scientific Imagination" that Tyndall urges the theory of the atomic constitution of matter as the only theory consistent with its objective reality. He takes it for granted that the alternative lies between the definite, tangible, solid atom on the one hand, and a shadowy abstraction—a "vibrating, multiple proportion, or a numerical ratio in a state of oscillation"—on the other. There is no doubt that the opinion thus expressed is shared by the great majority of physicists, as well as of ordinary untrained men. To the minds of most persons, as to the mind of Tyndall, the conception of matter involves the notion of definite, tangible, and indestructible solidity. It is the general tacit assumption that, of the three molecular states, or states of aggregation, in which matter presents itself to the senses—the solid, the liquid, and the gaseous—the last two are simply disguises of the first; that a gas, for instance, is in fact a group or cluster of solids, like a cloud of dust, differing from such a cloud only by the greater regularity in the forms and distances of the particles whereof it is composed, and by the fact that these particles are controlled in the case of a gas by their mutual attractions and repulsions, while in the case of the cloud of dust they are under the sway of extrinsic forces. And, while the transition of the three molecular states into each other in regular and invariable order is too obvious to be ignored, it is supposed that the solid is the primary, normal, and typical state of which the liquid and gaseous, or aëriform, states are simply derivatives, and that, if these states are considered as evolved the one from the other, the order of evolution is from the solid to the vapor or gas. In this view the solid form of matter is not only the basis and origin of all its further determinations —of all its evolutions and changes—but it is also the primary and typical element of its mental representation and conception.

While this view of the relation between the molecular states of matter is all but universally prevalent, it is not difficult to show that it is in irreconcilable conflict with the facts of scientific experience. All evolution proceeds from the relatively Indeterminate to the relatively Determinate, and from the comparatively Simple to the comparatively Complex. And (confining our attention, for the moment, to the two extreme terms of the evolution, the solid and the gas, and ig-

noring the intermediate liquid) a comparison of the gaseous with the solid state of matter at once shows that the former is, not the end, but the beginning of the evolution. The gas is not only comparatively indeterminate—without fixity of volume, without crystalline or other structure, etc.—but it also exhibits, in its functional manifestations, that simplicity and regularity which is characteristic of all types or primary forms. Looking, *first*, to the purely physical aspect of a gas —I speak, of course, only of gases which are approximately perfect, to the exclusion of vapors at low temperatures and of gases which are readily coercible: its volume expands and contracts inversely as the pressure to which it is subjected; its velocity of diffusion is inversely proportional to the square root of its density; its rate of expansion is uniform for equal increments of temperature; its specific heat is the same at all temperatures, and, in a given weight, for all densities and under all pressures; the specific heats of equal volumes of simple and incondensible gases, as well as of compound gases formed without condensation, are the same for all gases of whatever nature, and so on. In all these respects the contrast with both the liquid and solid forms, the relations of whose volumes, or structures, or both, to temperature and to mechanical pressure or other force are complicated in the extreme, is great and striking. But this contrast becomes still more signal, *secondly*, under the chemical aspect. We cannot, in any proper sense, assign the proportions of volume in which the combination of solids and liquids takes place—indeed, the combination of solids as such is impossible—and the numbers expressive of the proportions of the combining weights upon their face exhibit an appearance of irrelation and irregularity which the most sustained endeavors of scientific men (such as Dumas, Strecker, Cooke, L. Meyer, Mendelejeff, and Baumhauer) have been unable to obliterate. In the combination of gases, on the contrary, all is simplicity and order. "The ratio of volumes, in which gases combine, is always simple, and the volume of the resulting gaseous product bears a simple ratio to the volumes of its constituents" —such is the law of the combination of gaseous volumes known as the law of Gay-Lussac. By weight, the ratio of combination between hydrogen and chlorine is 1 to 35.5; by volumes, one volume of hydrogen combines with one volume of chlorine (the volumes being taken, of course, at the same pressures and temperatures) so as to form two volumes of hydrochloric acid. Oxygen and hydrogen combine in the proportion of 16 to 2 by weight; but one volume of oxygen combines with two volumes of hydrogen, forming two volumes of watery vapor. Nitrogen and hydrogen, whose atomic weights, so called, are 14 and 1 respectively, combine in the simple ratio of one volume of nitrogen to three volumes of hydrogen, the combination resulting in two volumes of gaseous ammonia. And carbon, whose 'atomic weight' is 12, though it cannot be actually obtained in gaseous form, is assumed by all chemists (for reasons not necessary to

state here) to combine with hydrogen in the ratio of one volume to four, so as to yield two volumes of marsh-gas.

It seems to be evident, then, that the typical and primary state of matter is, not the solid, but the gas. And, this being so, it follows that the molecular evolution of matter conforms to the law of all evolution in proceeding from the indeterminate to the determinate, from the simple to the complex, from the gaseous to the solid form. This is no longer a mere presumption; if the nebular hypothesis, so called, after being stripped of its non-essential features, is recognized as a true theory—as it is by all the prominent physicists of the day since the recent revelations of the spectroscope—the gaseous form of matter, in fact, precedes the liquid and solid forms in the order of Nature, and the solid is not the initial, but the concluding term of material evolution. Inasmuch, therefore, as the explanation of any phenomenon consists in the exhibition of its genesis from its simplest beginnings, or from its earliest forms, the gaseous form of matter is the true basis for the explanation of the solid form, and not conversely the solid for the explanation of the gas.

From the foregoing considerations I take it to be evident that the true relation between the molecular states of matter is the exact reverse of that universally assumed. The universality of this assumption, however, indicates that it is not due to a mere chance error of speculation, but to some natural bias of the mind. The question arises, therefore: What is the origin of this prevalent delusion respecting the constitution of matter? I believe the answer to this question to be exceedingly simple, and important in proportion to its simplicity. There are certain fallacies to which the human intellect is liable by reason of the laws of its growth which I propose to call *structural* fallacies, one of which is that the intellect tends to confound the order of the genesis of its ideas respecting material objects with the order of the genesis of these objects themselves. It is well known that the progress of our knowledge depends upon analogy—upon a reduction of the Strange and Unknown to the terms of the Familiar and Known. In a certain sense it is true, what has been often said, that all cognition is recognition. "Man constantly institutes comparisons," says Pott ("Etymologische Forschungen," ii., 139), "between the new which presents itself to him, and the old which he already knows." That this is so is shown by the development of language. The great agent in the evolution of language is metaphor—the transference of a word from its ordinary and received meaning to an analogous one. This transference of the name descriptive of a known and familiar thing to the designation of an unknown and unfamiliar thing typifies the proceeding of the intellect in all cases where it deals with new and strange phenomena. It assimilates these phenomena to those which are known; it identifies the Strange, as far as possible, with the Familiar; it apprehends that which is extraordinary

and uncommon in terms of that which is ordinary and common. But that which is most obvious to the senses is both the earliest and most persistent presence in consciousness, and thus receives the stamp of the greatest familiarity. Now, the most obtrusive form of matter is the solid, and for this reason it is that form which is first cognized by the infant intellect of mankind, and thus serves as the basis for the subsequent recognition of other forms. Accordingly we find that, on the early stages of human history, the solid alone was apprehended as material. It was long before even atmospheric air, obtrusive as it was in wind and storm, came to be known as a form of matter. To this day words signifying wind or breath—*animus*, *spiritus*, *geist*, *ghost*, etc.—are the terms denoting that which is the fundamental correlate of matter, even in the languages of civilized nations. And it is very questionable whether either the ancient philosophers or the mediæval alchemists distinctly apprehended any aëriform substance, other than atmospheric air, as material. It is certain that up to the time of Van Helmont, in the latter part of the sixteenth and the first decades of the seventeenth century, aëriform matter was not the subject of sustained scientific investigation.

It is obvious, then, that, while the progress of evolution in Nature is from the aëriform to the solid state of matter, the progress of the evolution of knowledge in the minds of men was conversely from the solid to the aëriform; and, as a consequence, the aëriform or gaseous state came to be apprehended as a mere modification of solidity. For the same reason, the first form of material action which was apprehended by the dawning intellect of man was the interaction between solids—mechanical interaction—and from this, again, it followed that the difference between the solid and the gas was apprehended as a mere difference of distance between the solid particles, as produced by mechanical motion.

Again: familiarity, in the minds of ordinary men, is universally confounded with simplicity. And, the explanation of a phenomenon consisting, as we have seen, in an exhibition of its genesis from its simplest beginnings, the mind, in its attempts to explain the gaseous form, naturally retraces the steps in the evolution of its ideas concerning matter —of its concepts of matter—back to the earliest, most familiar, and therefore apparently simplest form in which matter was and is apprehended, and assumes the solid particle, the *atom*, as the ultimate fact, as the primary element for all representation and conception of material existence.

This is not the place to develop the important consequences which flow from the total subversion of the prevailing concepts respecting the constitution of matter that, in my judgment, is inevitable. When it comes to be fully realized that an aëriform body is not a group of absolute solids, but is elastic to the core; that a gas is a gas throughout, and in its very essence; that in the simplest states of matter there

is no absolute residuum which is exempt from all change and remains constant amid all variation—when the relation of primordial matter to its structural, or rather formative, agencies is properly understood—the whole science of molecular statics and dynamics will press at once for thorough reorganization.

It may be proper, in this connection, before I proceed to the discussion of another topic, to say a few words about the ordinary mechanical explanation of the molecular states of matter, or states of aggregation, on the basis of the atomic theory. This explanation proceeds on the assumption that the molecular states are produced by the conflict of antagonistic central forces—molecular attraction and repulsion—the preponderance of the one or the other of which gives rise to the solid and gaseous forms, while their balance or equilibrium results in the liquid state. The utter futility of this explanation is apparent at a glance. Even waiving the considerations presented by Herbert Spencer ("First Principles," p. 60, *et seq.*) that, in view of the necessary variation of the attractive and repulsive forces in the inverse ratio of the squares of the distances, the constituent atoms of a body, if they are *in equilibrio* at any particular distance, must be equally *in equilibrio* at all other distances, and that their density or state, therefore, must be invariable; and, admitting that the increase or diminution of the repulsive force, *heat*, may render the preponderance of either force, and thus the change of density or state of aggregation, possible: what becomes of the liquid state as corresponding to the exact balance of these two forces in the absence of external coercion? The exact balance of the two opposing forces is a mere mathematical limit which must be passed with the slightest preponderance of either force over the other. All bodies being subject to continual changes of temperature, the equilibrium can at best be but momentary; it must of necessity be of the most labile kind. If the mechanical explanation of the molecular states were valid, all bodies would present the phenomena exhibited by arsenic under the action of heat—they would at once pass from the solid into the gaseous form, the intervening liquid state vanishing after the manner of all limits.

The notion of the essential solidity of matter of necessity leads to—indeed, at bottom, is identical with—the assumption of its absolute hardness or unchangeability of volume, and thus involves the theory of the atomic constitution of matter in its ordinary form. This assumption is connected with another fallacious bias of the mind, which results from the inability of the mind to consider phenomena otherwise than singly, and under some one definite aspect—the tendency to assign absolute limits to every series of material phenomena. It has been a favorite tenet, not only of metaphysicians but of physicists as well, that reality is cognizable only as absolute, permanent, and invariable, or, as the metaphysicians of the sixteenth and seventeenth centuries expressed it, *sub specie æterni et absoluti.* This proposition, like

so many others which have served as pillars of imposing metaphysical structures, is the precise opposite of the truth. All material reality is, in its nature, not absolute, but essentially relative. All material reality depends upon determination; and determination is essentially limitation, as even Spinoza well knew. A "thing in and by itself" is an impossibility. And I may add here (without dwelling upon it further, a discussion of this subject being foreign to my theme), the "thing *per se*" is not only impossible, according to the *criteria* of our intellect, but it is not the object of knowledge, in any sense, and cannot, therefore, be the legitimate subject of speculation. As Ferrier would say, we can neither know it nor be ignorant of it. I do not speak here merely of objects without relation to the intellect, in the sense of Ferrier's "Theory of Ignorance," but of objects without relation to each other. "We only know any thing," justly says John Stuart Mill ("Examination of Sir W. Hamilton's Philosophy," i., 14), "by knowing it as distinguished from something else; all consciousness is of difference; two objects is the smallest number required to constitute consciousness; a thing is only seen to be what it is by contrast with what it is not." Here, again, the doctrines of psychology are corroborated by the teachings of the science of language. "Words," says Rev. Richard Garnett ("Philological Essays," p. 282), "express the relations of things; and this, it is believed, is strictly applicable to every word in every language, and under every possible modification."

Among those who have had occasion of late to insist upon the relativity of all objective reality is Prof. Helmholtz. Speaking of the inveterate prejudice according to which the qualities of things must be analogous to, or identical with, our perceptions of them, he says ("Die neueren Fortschritte in der Theorie des Sehens," Pop. wiss. Vortraege II., 55, *et seq.*): "Every property or quality of a thing is in reality nothing else than its capability of producing certain effects on other things. The effect occurs either between connatural parts of the same body, so as to produce differences of aggregation, or it proceeds from one body to another, as in the case of chemical reactions; or the effects are upon our organs of sense and manifest themselves as sensations such as those with which we are here concerned (the sensations of sight). Such an effect we call a 'property,' its reagent being understood without being expressly mentioned. Thus we speak of the 'solubility' of a substance, meaning its behavior toward water; we speak of its 'weight,' meaning its attraction to the earth; and we may justly call a substance 'blue,' under the tacit assumption that we are only speaking of its action upon a normal eye. But, if what we call a property always implies a relation between two things, then a property or quality can never depend upon the nature of one agent alone, but exists only in relation to and dependence on the nature of some second object acted upon. Hence, there is really no sense in talking of properties of light which belong to it absolutely, indepen-

dently of all other objects, and which are supposed to be representable in the sensations of the human eye. The notion of such properties is a contradiction in itself. They cannot possibly exist, and therefore we cannot expect to find any coincidence of our sensations of color with qualities of light."

The fundamental truth which is implied in these sentences is of such transcendent importance that it is hardly possible to be too emphatic in its statement, or too profuse in its illustration. All quality is relation; all action is reaction; all force is antagonism; all measure is a ratio between terms neither of which is absolute; every objectively real thing is a term in numberless series of mutual implications, and its reality outside of these series is utterly inconceivable. A material entity, absolute in any of its aspects, would be nothing less than a finite infinitude. There is no absolute material quality, no absolute material substance, no absolute physical unit, no absolutely simple physical entity, no absolute constant, no absolute standard either of quantity or quality, no absolute motion, no absolute rest, no absolute time, no absolute space. There is no physical thing, nor is there a real or conceptual element of such a thing, which is either its own support or its own measure, and which abides either quantitatively, or qualitatively, otherwise than in perpetual change, in an unceasing flow of mutations. An object is large only as compared with another which, as a term of this comparison, is small, but which, as a term in a comparison with a third object, may be indefinitely large; and the comparison which determines the magnitude of objects is between its terms alone, and not between any or all of these terms, and an absolute standard. An object is hard as compared with another which is soft, but which, in turn, may be contrasted with a third still softer; and, again, there is no standard object which is either absolutely hard or absolutely soft. A body is simple as compared with the compound into which it enters as a constituent; but there is, and can be no physically real thing which is absolutely simple. Similarly, all changes of position or distance between two bodies are wholly relative, and it is a matter of purely arbitrary determination, which of them is taken as being at rest, and which as in motion. It is equally true to say that the earth falls toward the apple, and that the apple falls toward the earth.

I may observe, in this connection, that not only the law of causality, the persistence of force, and the indestructibility of matter, have their root in the relativity of all objective reality—being, indeed, simply different aspects of this relativity—but that Newton's first and third laws of motion, as well as all laws of least action, so called, in mechanics (including Gauss's law of movement under least coercion), are but corollaries from the same principle. And the fact that every thing is, in its manifest existence, but a group of relations and reactions, at once accounts for Nature's inherent teleology.

The truth that all our knowledge of objective reality depends upon the establishment or recognition of relations, has been proclaimed by innumerable thinkers, but, nevertheless, is constantly lost sight of, or ignored. There is nothing more interesting and instructive, than a review of the errors and perplexities that have been entailed by the rejection or disregard of this truth both upon metaphysical speculation, and upon physical science. The ontological vagaries spun from the proposition that all reality is in its last elements absolute, do not, of course, concern us here; there is, however, one form of this proposition which is so intimately connected with the main subject under discussion, that it is, perhaps, well to indulge in a passing allusion to it.

Leibnitz places at the head of his "*Monadology*" the principle that there must be simple substances, because there are compound substances. "*Necesse est*," he says, "*dari substantias simplices quia dantur compositæ.*" This enthymeme, though it has been long since exploded in metaphysics, is still regarded by many physicists as proof of the real existence of absolutely simple constituents of matter. Nevertheless, it is obvious that it is nothing but a vicious paralogism—a fallacy of the class known in logic as fallacies of suppressed relative. The existence of a compound substance certainly proves the existence of component parts which, *relatively to this substance*, are simple. But it proves nothing whatever as to the simplicity of these parts in themselves.

Among the most notable intellectual hobbles resulting from the attempt to deal with quantity as an absolute, self-determining entity are the various theories of infinitesimals in mathematics, and of the real basis of the differential and integral calculus. The consideration of these theories is beyond the limits of my task, which restricts me to the discussion of questions relating to physical science. But within these limits, it is by no means difficult to find conspicuous proof of the fact that the supposed physical constant of weight and volume, the "atom," is by no means the only absolute real term—the only finite infinitude—which is postulated by physical science in its most recent forms. How completely the minds of modern physicists are under the control of the conceit that physical entities, for purposes of their real apprehension, can be disentangled from the net-work of relations as a part of which they present themselves both to thought and to sense, is at once seen upon the most cursory examination of the remarkable speculative writings which have been published of late by eminent scientific men. I select from the many lectures and essays of this class which have fallen under my notice, a lecture delivered November 3, 1869, in the *Aula* of the University of Liepsic, by Dr. C. Neumann (Professor of Mathematics at the university, and well known as the author of several important contributions to the theory of Abel's Integrals), "On the Principles of the Galileo-Newtonian Theory."[1] The

[1] "Ueber die Principien der Galilei-Newton'schen Theorie. Akademische An-

first part of this lecture is without special interest for us here; but the second part is of the greatest possible significance as an exhibition of the tendency of physicists to postulate determinate last elements, absolute spatial limits, and invariable physical standards in the construction of material phenomena. For this reason, I shall take the liberty of reproducing, as literally as is possible in a translation, the most important passages of this part of the lecture.

"The principles of the Galileo-Newtonian theories," says Prof. Neumann (*loc. cit.*, p. 11), "consist in two laws—the law of inertia proclaimed by Galileo, and the law of attraction added by Newton. . . . A material point, when once set in motion, free from the action of an extraneous force, and wholly left to itself, continues to move in a straight line so as to describe equal spaces in equal times. Such is Galileo's law of inertia. It is impossible that this proposition should stand in its present form as the corner-stone of a scientific edifice, as the starting-point of mathematical deductions. For it is perfectly unintelligible, inasmuch as we do not know what is meant by "motion in a straight line," or, rather, inasmuch as we do not know that the words "motion in a straight line" are susceptible of various interpretations. A motion, for instance, which is rectilinear as seen from the earth, would be curvilinear as seen from the sun, and would be represented by a different curve as often as we change our point of observation to Jupiter, to Saturn, or another celestial body. In short, every motion which is rectilinear with reference to one celestial body, will appear curvilinear with reference to another celestial body. . . . . .

"The words of Galileo, according to which a material point left to itself proceeds in a straight line, appear to us, therefore, as words without meaning—as expressing a proposition which, to become intelligible, is in need of a definite background. *There must be given in the universe some special body as the basis of our comparison, as the object in reference to which all motions are to be estimated;* and only when such a body is given, shall we be able to attach to those words a definite meaning. Now, what body is it which is to occupy this eminent position? Or, are there several such bodies? Are the motions near the earth to be referred to the terrestrial globe, perhaps, and those near the sun, to the solar sphere? . . . .

"Unfortunately, neither Galileo nor Newton gives us a definite answer to this question. But, if we carefully examine the theoretical structure which they erected, and which has since been continually enlarged, its foundations can no longer remain hidden. *We readily see that all actual or imaginable motions in the universe must be referred to one and the same body.* Where this body is, and what are

trittsvorlesung gehalten in der Aula der Universität, Leipzig, am 3. November, 1869. Von Dr. C. Neumann, ord. Professor der Mathematik an der Universität, Leipzig," etc. Leipzig, B. G. Teubner, 1870.

the reasons for assigning to *it* this eminent, and, as it were, sovereign position, these are questions to which there is no answer.

"*It will be necessary, therefore, to establish the proposition, as the first principle of the Galileo-Newtonian theory, that in some unknown place of the universe there is an unknown body—a body absolutely rigid and unchangeable for all time in its figure and dimensions. I may be permitted to call this body* "THE BODY ALPHA." *It would then be necessary to add that the motion of a body would import, not its change of place in reference to the earth or sun, but its change of position in reference to the body Alpha.*

"From this point of view the law of Galileo is seen to have a definite meaning. This meaning presents itself as a second principle, which is, that a material point left to itself progresses in a straight line—proceeds, therefore, in a course which is rectilinear in reference to the body Alpha."

It will be observed that the assumption which underlies all this reasoning of Prof. Neumann is that, to conceive motion as real, it is necessary to conceive it as absolute—an assumption in every respect analogous to that of Prof. Tyndall, according to which the reality of matter implies its constitution from absolute, unvarying elements. The logical parentage of the body Alpha is precisely the same as that of the "atom." And I may add that the assumption of Prof. Neumann is the tacit assumption of almost all the physicists and philosophers of the day, although it is not usually developed to its last consequences. It is one of the tasks of Herbert Spencer, for instance, to exhibit the contradictions involved in the essential relativity of motion. "A body impelled by the hand," says Spencer ("First Principles," chap. iii., § 17), "is clearly perceived to move, and to move in a definite direction: there seems at first sight no possibility of doubting that its motion is real, or that it is toward a given point. Yet it is easy to show that we not only may be, but usually are, quite wrong in both these judgments. Here, for instance, is a ship which, for simplicity's sake, we will suppose to be anchored at the equator, with her head to the west. When the captain walks from stem to stern, in what direction does he move? East is the obvious answer—an answer which for the moment may pass without criticism. But now the anchor is heaved, and the vessel sails to the west with a velocity equal to that at which the captain walks. In what direction does he now move when he goes from stem to stern? You cannot say east, for the vessel is carrying him as fast toward the west as he walks to the east; and you cannot say west, for the converse reason. In respect to surrounding space, he is stationary, though to all on board the ship he seems moving. But now are we quite sure of this conclusion? Is he really stationary? When we take into account the earth's motion round its axis, we find that, instead of being stationary, he is traveling at the rate of 1,000 miles per hour to the east; so that neither the

perception of one who looks at him, nor the inference of one who allows for the ship's motion, is any thing like the truth. Nor, indeed, on further consideration, shall we find the revised conclusion much better. For we have forgotten to allow for the earth's motion in its orbit. This being some 68,000 miles per hour, it follows that, assuming the time to be mid-day, he is moving, not at the rate of 1,000 miles per hour to the east, but at the rate of 67,000 miles per hour to the west. Nay, not even now have we discovered the true rate and the true direction of his movement. With the earth's progress in its orbit, we have to join that of the whole solar system toward the constellation Hercules; and, when we do this, we perceive that he is moving neither east nor west, but in a line inclined to the plane of the ecliptic, and at a velocity greater or less (according to the time of the year) than that above named. To which let us add that, were the dynamic arrangements of our sidereal system fully known to us, we should probably discover the direction and rate of his actual movement to differ considerably even from these. How illusive are our ideas of motion is thus made sufficiently manifest. That which seems moving proves to be stationary; that which seems stationary proves to be moving; while that which we conclude to be going rapidly in one direction turns out to be going much more rapidly in the opposite direction. And so we are taught that what we are conscious of is not the real motion of any object, either in its rate or direction, but merely its motion as measured from an assigned position—either the position we ourselves occupy or some other. *Yet in this very process of concluding that the motions we perceive are not the real motions, we tacitly assume that there are real motions.* In revising our successive judgments concerning a body's course or velocity, we take for granted that there is an actual course or an actual velocity—*we take for granted that there are fixed points in space with respect to which all motions are absolute; and we find it impossible to rid ourselves of this idea. Nevertheless, absolute motion cannot even be imagined, much less known. Motion, as taking place apart from those limitations of space which we habitually associate with it, is totally unthinkable.* For motion is change of place; but, in unlimited space, change of place is inconceivable, because place itself is inconceivable. Place can be conceived only by reference to other places; and, in the absence of objects dispersed through space, a place could be conceived only in relation to the limits of space; whence it follows that in unlimited space place cannot be conceived—all places must be equidistant from boundaries that do not exist. Thus, while we are obliged to think that there is an absolute motion, we find absolute motion incomprehensible."

I have quoted this elaborate exposition from the text of Mr. Spencer, because it most clearly evinces the difficulty experienced even by those who habitually insist upon the relativity, not only of all our actual knowledge, but also of all our possible cognition, in freeing

themselves from the prejudice that nothing can be real which is not absolute.

Prof. Neumann is not content with showing, or attempting to show, that the reality of motion necessitates its reference to a rigid body unchangeable in its position in space, but he seeks to verify this assumption by asking himself the question what consequences would ensue, on the hypothesis of the mere relativity of motion, if all bodies in space, except one, were annihilated. "Let us suppose," he says (*loc. cit.*, p. 27), "that among the stars there is one which consists of fluid matter, and which, like our earth, is in rotary motion around an axis passing through its centre. In consequence of this motion, by virtue of the centrifugal forces developed by it, this star will have the form of an ellipsoid. What form, now, I ask, will this star assume if suddenly all other celestial bodies are annihilated?

"These centrifugal forces depend solely upon the state of the star itself; they are wholly independent of the other celestial bodies. These forces, therefore, as well as the ellipsoidal form, will persist, irrespective of the continued existence or disappearance of the other bodies. But, if motion is defined as something relative—as a relative change of place of two points—the answer is very different. If, on this assumption, we suppose all other celestial bodies to be annihilated, nothing remains but the material points of which the star in question itself consists. But, then, these points do not change their relative positions, and are therefore at rest. It follows that the star must be at rest at the moment when the annihilation of the other bodies takes place, and therefore must assume the spherical form taken by all bodies in a state of rest. A contradiction so intolerable can be avoided only by abandoning the assumption of the relativity of motion, and conceiving motion as absolute, so that thus we are again led to the principle of the body Alpha."

This reasoning of Prof. Neumann is irrefutable, if we concede the admissibility of his hypothesis of the destruction of all bodies in space but one. But the very principle of relativity forbids such an hypothesis. The annihilation of all bodies but one would not only destroy the *motion* of this one remaining body and bring it to rest, as Prof. Neumann sees, but it would also destroy its very *existence* and bring it to naught, as he does not see. A body cannot survive the system of relations in which alone it has its being; its *presence or position* in space is no more possible without reference to other bodies than its *change of position or presence* is possible without such reference; and, as I have abundantly shown, all properties of a body are in their nature relations, and imply terms beyond the body itself. The case put by Prof. Neumann is thus an attestation of the truth that the essential relativity of all physical reality implies the persistence both of force and of matter, so that his argument is a demonstration, not of the falsity, but of the truth of the principle of relativity.

As there is no Unconditional in subjective thought, so there is no Absolute in objective reality. There is no absolute system of co-ordinates in space to which the positions of bodies and their changes can be referred; and there is neither an absolute measure of quantity, nor an absolute standard of quality. *There is no physical constant.*

## A POWDER-MILL EXPLOSION.

By WILLIAM AIKMAN.

I PROPOSE to have a talk about an explosion of a powder-mill. It has never been my hap to see one described, and it has seemed to me that an account of an occurrence of this sort, which does not come under common observation, might not be uninteresting.

While explosions are not the final cause of powder-works—that is, while they are not built expressly for the purpose of exploding—yet they are located with reference to it. It was the fortune of this writer to reside for a number of years within a few miles of the powder-manufactories of the Messrs. Dupont, of Delaware, and so had opportunities of observing the thing of which he speaks. These works will probably be a fair example of others.

These powder-mills, perhaps the most extensive in the country, are about three miles above the city of Wilmington, on the banks of the Brandywine River. The position was selected, some fifty or more years ago, by the father of the present proprietors. It is one of the most beautiful in this whole land. The river flows through an exquisite valley, where at every step some new beauty of wood and hill enchants the eyes.

The powder-works are placed at wide intervals for perhaps a half mile along the banks. They are so secluded and hidden that they are never seen or known to be there by an ordinary or uninformed traveler. Should you be riding along one of the hilly and beautiful roads near the mills, you would not only find nothing to suggest their proximity, but could only by inquiry discover the roads that lead to them.

The elder Dupont, father of the late illustrious Admiral Dupont, was a man of remarkable energy and business ability. In nothing did he show his character and foresight more than in the selection of the location of these mills. During the administration, or after it, of President Jefferson, Dupont came to this country from his native France with the purpose of establishing a manufactory of gunpowder in some favorable location. He found his way to Virginia, and made the acquaintance of Jefferson, who cordially welcomed him to the hospitalities of Monticello.

Anxious to promote the prosperity of that noble State, Jefferson urged upon Dupont Virginia as the place where his contemplated works should be established, and detained him with the courtesies of his home until he could exhibit to him the capabilities and attractions of the country.

Dupont accepted the invitation, and willingly and carefully examined the various places brought under his notice. After a few weeks of inspection and exploration, he reluctantly informed Jefferson that he could not see his way clear to settle in Virginia.

"Is it that the country is not favorable?" asked his entertainer.

"No," was the reply; "it is magnificent."

"Cannot favorable locations be procured? Is not water-power abundant? Cannot materials be found?"

"Yes, yes, but I do not like one thing that I find here."

"But what is that?"

"It's your institution of slavery. I cannot settle where it will be around me."

So Dupont came north, and the powder-manufactories were not established in Virginia.

The city of Paterson, near New York, was then a small village, with its glorious falls of the Passaic not utilized to death as they are to-day, and without a manufactory of any importance within its precincts. Dupont was freely offered a location there, and was strongly inclined to accept it. Every thing was favorable; the position of the land, the unbounded facilities of water-power, ease of transportation, accessibility to a large city, all pointed out the desirableness of the locality; but the sagacious man declined all offers.

"I see," said he, "that this beautiful spot will not remain many years as it is now. Before long, a city or town will grow up just here; extensive manufactories, attracted by this unlimited supply of water, with so many feet of fall, will line the banks of this river. When that time comes, the inhabitants will not brook the presence of a powder-mill, and I, after years of labor, and when all my works are established, will be compelled to move off and away. I must find some place where I can reasonably hope to remain undisturbed."

The secluded banks of the Brandywine, in Delaware, invited him, and the works were erected in its quiet valley.

The tract of land first purchased was large, occupying both banks of the river. It has, in the lapse of years, been gradually increased in size. The Duponts never sell, but are always ready to buy land which lies in their vicinity. The same policy which shaped the action of the father has been continued by the sons—to acquire a property so extensive that no neighboring proprietor can be near enough to desire the removal of their works or be injured by their proximity. This they have accomplished. The country, for perhaps a mile on either side of the Brandywine River, is in their possession, and no one

has a residence, except by their consent, within the possibility of harm from an explosion in their works.

Thus, while such explosions are more or less frequent, the detonation of one of them, if it be not of special violence, excites only the passing remark of a dweller in the neighboring city of Wilmington, and never injures any one outside the works.

Not only is the general location selected, but the various buildings of these powder-manufactories are placed, in reference to the ever-present danger of an explosion. The works are not connected with one another in one great building, or in a connected series of buildings. They are built along the river-banks for over half a mile on either side, and with so much of distance between them that an explosion in one does not ordinarily communicate itself to another, and its destructive effects do not extend beyond the immediate vicinity of the building in which it occurred.

The buildings themselves are constructed carefully with reference to these accidents. They—at least those where the process of manufacture reaches the stage of danger—are built of stone, with three massive walls of solid masonry some ten or twelve feet thick. The fourth side, that which looks toward the river, is made of light framework. The roof is constructed as simply as possible, and is laid upon the walls, and not built into them.

The design of this method of construction may be readily seen. If an explosion occurs, the boarded roof and side of the building readily yield, and are blown into the river, while the massive walls of the other three sides withstand the shock. The building is like a huge mortar. By this additional precaution, the lateral effects of the explosion are prevented, and the buildings on either side are measurably protected.

These precautionary measures, however, are not always effectual. As a general thing—for explosions of greater or less violence are not infrequent—a single dull, heavy detonation is heard, and it is almost unnoticed by those residing in the neighborhood. If slight, it may readily be taken for the noise of a blast in the quarries near by. As, in certain stages of the manufacture, the machinery is set in motion, and the workman leaves the room when the danger is most imminent, life is not necessarily lost by the accident. The only harm that has occurred is the loss of the simple machinery, the materials, and the lighter portion of the building.

Sometimes the case is very different. I have a very vivid remembrance of one. It was the first and the most severe of which I had any experience.

I was sitting with some friends in the parlor of my house, at about eleven o'clock in the morning, when there came a sudden jar and a fearful shock of some very heavy body falling, as I thought, upon the piazza, which ran along the rear of the house. I started from my

seat and toward the door, to see what had happened there, but had scarcely risen when another concussion and a mighty detonation came. I supposed that a very heavy piece of artillery had been discharged in the street, just in the rear of the house. Before I could reach the door, but a few feet away, there came another detonation and another terrific jar, which shook, as the others had done, the house to its foundations. The three reports were in such rapid succession as to be almost simultaneous, but thought was quicker than they, and leaped from supposition to supposition in an instant. The last concussion dissolved my doubts as to the origin of those that had preceded it, and I at once looked in the direction in which I knew the powder-mills to lie.

A spectacle of exquisite beauty and sublimity met my eyes, which will abide in my memory forever. I can hardly expect to convey to the reader the impression which it made upon me. Towering in the heavens, sharply defined against the deep-blue sky, was a column of dazzling white, perhaps a mile in height, and a thousand feet in diameter. Its sides were evenly cut and in perfect symmetry through the whole length of the marvelous column, till they spread out on either side at the top in a broad, palm-like canopy. The mid-day sun was shining upon it, and lighting it up with an unearthly splendor, while it seemed to stand almost over us. We gazed awe-struck and entranced upon it, and could easily think of that pillar of cloud that, in the olden time, stood in its awful majesty in front of the camp of Israel.

It was so vast that it seemed close at hand, although it was three miles away. We watched it silently till it slowly changed its form, and gradually drifted in great cumulous clouds away. It was a vision of singular and glorious beauty, such as I never expect to see again.

In this instance three buildings had been destroyed. The shock of the explosions was exceedingly marked and peculiar, different from any thing that I had previously known. It had a sort of pervasive character that suggested the cause as being immediately at hand. My first impression was not of something at a distance, but rather of the jar of a heavy body falling within four or five feet of where we were sitting, and, when it was repeated, of a cannon discharged close by the house. It seemed to be underneath and all around—to fill the very earth and air.

This pervasive character of the shock is very remarkable. It is the same in all that I have heard. It seems to be felt scarcely more violently in the immediate vicinity of the place where it occurred than miles away. In this case we were between three and four miles off, and yet the explosion could scarcely have been more startling and severely felt, or have seemed nearer, to those who were within a few rods of the place. Indeed, on certain occasions, the violence of the shock is felt much more at a distance than close at hand. In one instance that I

remember, the detonation and concussion were felt and heard distinctly and severely in Philadelphia and in Chester County, Pennsylvania, some thirty miles away, while they were scarcely noticed in Wilmington.

The sound and shock of these explosions must be strikingly similar to those of an earthquake. A few years since—it was on the very day that Chicago was burning—a severe shock of an earthquake was felt in Wilmington, Del., and its vicinity. It is described to me, by those who experienced it, as peculiarly alarming. The concussion was terrific, shaking the houses, opening doors, disturbing furniture, and the boom of the report was exceedingly loud and startling. In an instant all instinctively sprang to their western windows, and almost at once on every accessible roof spectators were gazing toward the northwest, the direction in which the Dupont powder-works are situated. The universal impression was, that there had been an explosion of unusual violence at those works. It was only when, after a time, no column of smoke was seen to rise, that any other explanation was suggested. The noise and the concussion were precisely like what had often been heard before on such an occasion.

The pervasive character of the sound and the shock in both the earthquake and the explosion of a powder-magazine are probably due to the same cause. They are propagated along the line of rocky strata. A continuous stratum of rock extends from the Brandywine to Philadelphia and its neighborhood, and this gives an obvious explanation to the fact, to which allusion has already been made, that the detonation and concussion are heard quite as distinctly as, and sometimes more so, at a distance, than, at a point nearer at hand.

I was curious to witness the effects of an explosion at the place where it occurred, so I set out at once for it. A great concourse was thronging the avenue leading toward the powder-mills, and dotting the fields which lay between them and the city. There was no time to be lost in hiring a vehicle; so, giving some specimens of tall pedestrianism, learned of yore in the streets of New York, I was soon in advance of the crowd, and, in company with a young and wiry Scotchman, whom I could not outwalk, was over the beautiful hills and through the woods which skirt the Brandywine, and at the place.

It was difficult, indeed, as I think of it now after some years, quite impossible, to realize what had taken place not an hour before. The day was at its noon, and the lovely valley was sleeping in quiet beauty. All was perfectly still, with nothing to suggest the terrible occurrence, except it might be those two or three rounded heaps yonder, over which a white canvas sheet was thrown. Under them lay the poor mutilated remains of what a little while ago were stalwart men. It was not good for loved one or stranger to look upon them now!

What struck me more than any thing else was the peculiar air of cleanliness and order that was over the place. Every thing, trees,

stones, road-bed, were all blackened, but all were smoothly swept. It seemed as if some time before there had been a fire which had blackened every thing, and that some one had gone round afterward, and, carefully gathering up and conveying away all the *débris*, had scrupulously swept the whole with brooms, leaving only the soot-stains behind.

Nothing of the sort had been done. Here was simply the result of the storm that had a little while before swept the spot. Usually, the force of the explosion is so great that no *débris* can be left behind. It is simply hurled out of existence. There are no broken boards or pieces of shingle, or bits of wood, to be found. They vanish in an instant. The ground itself has a singularly smoothed appearance, as if beaten down and rounded off.

There were few questions to be asked. On these occasions the proprietors and workmen are reticent, and information is not readily accessible. Indeed, inquiries as to the cause of the explosion are generally useless. If it has been through the agency of a careless workman, he is not there to tell the tale. The man nearest, and most acquainted with the fact, is probably the one who in an instant passes out of life, often totally vanishes from human sight, not even a fragment of his body remaining behind.

That many of these accidents are caused by the carelessness of workmen, there can be no doubt. It is needless to say that the utmost precaution is taken to guard the safety of the men and the works, such as floors flooded with water, shoes in which only copper nails are used, etc. The reader will perhaps smile when we say that *smoking* is absolutely prohibited. Yet, incredible as it may appear, the authority of the proprietors is absolutely necessary to enforce this prohibition. A proprietor of a powder-mill once said to me, that in the face of the ever-present danger, and of the most positive orders, it was impossible to prevent the men, at times, from taking their lighted pipes into the works; that he had detected the men thrusting their lighted pipes into their jacket-pockets to escape observation, as he had unexpectedly come upon them! A triumph of art—to smoke one's pipe in a powder-mill, and "the boss not find it out!"

Once in a while, on some special occasion, the pipe of some such cunning fellow goes suddenly out, and he with it. He does not linger to tell how it happened.

It might be supposed that it would be extremely difficult to find men in sufficient numbers to carry on a business so hazardous, in which the workman's life is in such constant danger. But no such difficulty is experienced. There are always more applicants than places for them to fill. As in every business, however unpleasant or unwholesome, there will always be found men who are more than ready for the work.

## SKETCH OF J. D. HOOKER, F.R.S., LL.D.

AMONG the scenes of interest near London which earliest attract the foreign visitor, is the magnificent Botanical Garden at Kew. It occupies 300 acres, which are crowded with the wealth of the vegetable kingdom, and forms the most extensive and perfect horticultural establishment in the world. It has three museums, containing upward of 50,000 objects of rare scientific interest exquisitely arranged, the completest botanical library ever yet brought together, a series of ample and admirably-constructed hot-houses, a pinetum, a water-lily aquarium, an extensive and richly-stocked arboretum, fern-houses, both tropical and temperate, an orchid-house, a house for begonias and gesneracea, together with a variety of other greenhouses and extensive plots of ground covered with herbaceous plants, and beautified to perfection. Kew Garden is one of the most popular places of resort in England. Some 700,000 people visit it annually, and the least educated of all this multitude cannot pass through it without learning something. The exotic plants nurtured in the hot-houses; the indigenous and naturalized plants blooming in the gardens; the dried specimens preserved in the herbarium; the various objects of curiosity treasured up in the three museums of economic botany—vie with each other in claiming the attention of even the most indifferent observer.

Learned philosophers and young children can equally find there abundant objects replete with interest for each, and worthy of lengthened contemplation: one loiters to examine curiosities of vegetation, such as the inner bark of "traveler's joy" (*Clematis vitalba*), used by the Swiss as a vegetable sieve for straining milk; or the inside of the towel-gourd, used in the West Indies as a sponge or a scrubbing-brush. There is an orange-tree, such as in the island of St. Michael produces 20,000 oranges in a year. Here is the caricature-plant, with the whimsical variegation of its leaves; the telegraph-plant, with the jerking of its lateral leaflets like the signals of the old semaphore; the tuberose, exhaling the most delicious perfume, and the stinking carrion-flower of South Africa; the pitcher-plant, each blossom containing half a pint of water and a swarm of drowned insects; and the Venus's flytrap, which springs its toothed leaves together for the capture of gnats and flies. At every turn and nook there are curiosities to excite the observant, and gratify the seeker for systematic, economic, or descriptive botanical knowledge.

Kew has been a place of plants, a nursery or seed-plot for the study of floriculture and horticulture, for more than a hundred years. It was a royal property, being purchased in 1730 by Frederick Prince of Wales, the great-grandfather of the present queen. The original

director of Kew Gardens was William Aiton, who had charge of it for thirty years, and died in 1793. He was succeeded by his son Townsend Aiton, who held the position for forty-eight years, when he resigned in 1841. Up to this time the establishment had been much restricted, but it was now given up by the royal family to the charge of the government, in the interests of science, and for the advantage of the people.

Sir William Jackson Hooker, Professor of Botany in the University of Glasgow, became director in 1841, and he then commenced that wonderful series of transformations which in the course of his twenty-four years' directory made Kew Gardens the first establishment of its kind in the world; while its character has not only been worthily sustained, but very appreciably expanded, advanced, and elevated, by his son and successor, the subject of the present sketch.

Dr. Joseph Dalton Hooker was born June 30, 1817. He was an only son, and his mother was a woman of ability, who shared in the scientific and artistic reputation of her husband. Educated under the scrutiny of his parents, the subject of this memoir was prepared from the outset for his career as a botanist and a scientific observer. Destined at first for the medical profession, young Hooker took his medical degree at an early age, but, under the influence of his hereditary preference for botany, the profession was given up, and he took to science. His medical education was, however, of great value to him in his subsequent experience both as botanist and traveler.

His first adventure in any public capacity as a botanical inquirer was one that eminently befitted him in his then twofold character of a practitioner of the healing art and as a purely scientific investigator. This was in 1839, when, having but just entered upon his twenty-second year, he took part as assistant-surgeon and naturalist on board the Erebus in the expedition sent out, under the command of Sir James Ross, to the Antarctic Ocean. Ostensibly Dr. Hooker's position throughout that memorable voyage was that of a medical officer on one of her majesty's ships-of-war: in reality his especial object all the while was to study the botany of the various regions touched at in those remote portions of the antipodes in the course of the expedition.

It is well to remember that Hooker received, during this four years' voyage, only the moderate pay accruing to him as a medical officer, his outfit being provided by his father, as well as his books and his instruments. Throughout the whole of that period, moreover, Sir William defrayed the expenses constantly incurred by his son when on shore, both in traveling and in collecting, notwithstanding the whole of the fruits of his labor, thus accumulated at considerable cost, were sought out for no private end, but for the advantage of a national establishment. Even after his return homeward, Dr. Hooker magnanimously determined to forego all claim to promotion in the royal navy, devot-

ing four years more to the classification of the treasures he had brought back with him at the close of the expedition. The result of these eight years of toil was visible, in the end, in his splendid publication of the "Flora Antarctica." The comparisons therein drawn of the new plants brought home by Dr. Hooker in great abundance, with the species already familiar to botanists in other parts of the world, helped apparently to realize to naturalists the laws, hitherto but dimly conjectured, regulating the distributing of plants over the surface of the globe.

Prior to entering upon the second of his many memorable expeditions of research as a botanical collector, Dr. Hooker held the position of botanist to the geological survey of Great Britain. On his return homeward, Dr. Hooker gave to the world, in 1851, as the literary fruits of his long journeyings, the two important volumes of his "Himalayan Journals." The three subsequent years were employed by him in arranging his Indian collection. Immediately upon his coming back, he had, moreover, resumed his labors as an assistant to his father at Kew Gardens. Besides this, for nine years together, beginning with 1851 and ending with 1860, Dr. Hooker was employed by the Lords of the Admiralty in editing a series of publications in which were recounted, in chronological sequence, the various botanical discoveries of a number of notable voyagers, from Captain James Cook down to Dr. Joseph Hooker himself. At intervals during the years thus occupied, he entered upon several other important journeys to different parts of the European Continent, visiting, besides these, at other periods, the north of Africa and the far West of the great Continent of America.

Dr. Hooker, in 1855, received the appointment of assistant-director of the Botanical Gardens, with a salary of £400, without any residence. Sir William Hooker was at that time seventy years of age, and was, therefore, fully entitled to have the assistance of his son thus secured to him by the government. Three years after, he had his salary increased to £500 a year, with use of a residence. His father died in 1865, aged eighty-one.

As an example of industry, during the directorship of the Hookers more than 130 costly volumes, treating upon all branches of botany, have been issued to the world from the Kew establishment. Living plants to the number of between 8,000 and 9,000 annually have, within the same period, from that grand central point of distribution, been sent to various parts of the globe—new and often most precious additions to the treasures of Kew being constantly sought out and brought homeward through the agencies employed by the ever-vigilant directors. The correspondence involved in this constant interchange of communications between them and the botanists of both hemispheres has been such that 40,000 letters, it has been calculated, have, in the course of the comparatively brief interval we are referring to, been

received, and have been answered, nearly every one of them, by the hands of the directors themselves.

The history of science furnishes few instances like this of prolonged devotion to a public enterprise so splendidly carried out as to become a national honor and a benefaction to the scientific world. The development of Kew is a noble work of art requiring genius, taste, enthusiasm and perseverance, as well as knowledge. The world had to be ransacked to accumulate his treasures, and those treasures are for the most part living things. The Hookers, father and son, have not only given a generation of incessant work to the organization of the Kew Gardens, but they have done it at a constant and large self-sacrifice. They contributed effort and money to the perfection of a work which is an honor to the government, and one would think that the least the government could do would be fairly to admit the obligation. But, under the Gladstone administration, the office of Commissioner of Public Works was conferred upon a narrow-minded blockhead named Ayrton, who looked upon science and its interests with the prejudice and contempt characteristic of politicians. His office placed him in charge of the Botanical Gardens as the superior to whom its director was responsible, and he began a course of meddlesome interference with the affairs of the establishment which was so insulting to Dr. Hooker, and would have been so injurious to the place, that the leading scientific men of England united in a protest to the government. The paper, signed by Lyell, Paget, Huxley, Darwin, and Tyndall, was drawn up by the latter gentleman, and presented the government in such a disgraceful attitude before the world, that Parliament took up the subject and put a check to the offensive treatment of Dr. Hooker by the arrogant and supercilious minister of public works. A man's work must be his monument, and Dr. Hooker may be well content with that; but, after what has taken place, the Government of England owes it to its own dignity to recognize in some fitting way the eminent services of the director of the Botanical Gardens.

Dr. Hooker stands high, not only as an indefatigable explorer, but also as a philosophic botanist; and he long since espoused the doctrine that the species of the world's present flora have been derived by descent and divergent modifications from ancient vegetable forms. He married a daughter of the Rev. J. S. Henslow, Professor of Botany in the University of Cambridge; and his wife is not only herself an accomplished botanist, but she shares in her husband's labors, and has recently translated a splendid work upon the subject from the French language.

# EDITOR'S TABLE.

*A NEW SCIENTIFIC SCHOOL.*

A NEW institution, of great promise, has just been added to our increasing list of scientific and technological schools. Pardee Hall, a spacious and well-appointed edifice, costing $250,000, and the gift of Mr. Ario Pardee, was added to Lafayette College, at Easton, Pa., with imposing ceremonies of dedication, on the 21st of October. The structure has a front of 256 feet in length, with lateral wings, the centre building being five stories in height. It is constructed of Trenton brownstone, with trimmings of light Ohio sandstone. The lecture-rooms, cabinets, models, laboratories, apparatus, and the facilities for studying mining operations, are on the amplest scale. In chemistry, the establishment is especially strong. Many thousand dollars have been expended for chemical apparatus, much of it made to order in Germany and France; there is desk-room for nearly 250 students, and, by the introduction of the latest improvements, the laboratories are claimed to be the completest in America. It is stated that Mr. Pardee, who is largely engaged in mining operations, has contributed not less than half a million dollars to Lafayette College, which, under the presidency of the Rev. Dr. Cattell, has reached a very prosperous condition.

We publish a portion of Prof. Raymond's able dedicatory address, regretting that we have not space for the whole of it. It will be seen that he takes broad ground, and insists upon a liberal culture for the special students of science. We hope that what he says upon this subject foreshadows the policy of the new institution. The narrowness of the curriculum of our technological schools, which aim, like our business colleges, and like medical and legal schools, to prepare immediately for practical professional life, is a very serious objection, as it favors the false idea that scientific education has no wider basis than sheer pecuniary utility. That scientific schools, as those of agriculture, mining, and engineering, have hitherto been liable to this reproach, is undeniable. But that is certainly no reason why a course of education that is marked out with predominant reference to professional pursuits should not be at the same time broad and liberal. Allowances, of course, must be made for the difficulties of initiating a new system, which had to answer the question "Of what use?" at the outset. Healthful beginnings are ever small, and it was inevitable that the traditional system, of culture, which ostentatiously repudiated every thing like practical uses, should make the most of the poverty and narrowness of the scientific curriculum. But the first stage in the history of the scientific schools is now past. They have ceased to be experiments; their need is acknowledged, and they are being established on the most munificent scale of endowment. It is now demanded that the "new education" shall be widened, harmonized, and adjusted, so as to meet the full requirements of a liberal mental cultivation. Let the basis of training be modern and scientific, instead of ancient and classical, and, the new standpoint being taken, let the courses of study be widened, so as to include moral, literary, and æsthetic agencies of training. Of course, with the growth of the new, there must be riddance of the old, but the old educational tree has plenty of decayed branches and dead wood, the cutting away of which will reinvigorate its whole life.

### SCIENTIFIC LECTURES.

THAT lectures will always continue to be, as they always have been, a valuable mode of public instruction, there can be little doubt; but, that what is called the lecture system is going to prove an agency of national regeneration, may be seriously questioned. In so far as it is in any sense a system, it has degenerated to a mere catering to public amusements. The platform is crowded with readers, singers, declaimers, dramatists, and buffoons, and the "course of lectures" is transformed into a "series of entertainments." People cannot have their intellects on the rack forever, you know; they must have a little relaxation. This tendency to pander to a low public taste, and, under the respectable name of lectures, to degrade the platform to purposes of mere speculation, ought in every way to be withstood. Let amusements stand upon their own basis, and not appeal to the public under false pretenses. Lectures upon science, history, or philosophy, to be really valuable, should be given in courses with sufficient fullness to produce some depth of impression. It is in this way that such men as Lardner, Mitchell, and Tyndall, have helped on the work of public education. We spoke last month in commendation of Mr. Proctor, as a popular teacher of astronomy; and, to those who desire lectures of a similar first-class character in another and widely-different field, we now recommend Prof. Edward S. Morse, of Salem, Mass. Prof. Morse's department is zoology, in which he is an original investigator, of excellent standing, and therefore thoroughly acquainted with the actual phenomena of his subject. As a teacher of natural history, he has rare merits, a lively and wide-awake manner, by which he keeps the attention of his audience; simple and untechnical language, suited to make everybody understand him; and remarkable skill in the rapid and accurate drawing of diagrams upon the black-board. To most lecturers this is an interruption and a bore. They have to stop speaking while they are drawing, to outline the object they are dealing with. Prof. Morse makes his figures rapidly and elegantly, using both hands at once, and keeps up an unbroken flow of talk. The advantage of being thus able to hold his audience, by engaging two senses at once, is very great; for, not only is he more secure of the listeners' apprehension by creating his forms before the eye at the same time they are described to the ear, but the pleasure of full mental occupation is also in a high degree favorable to the retention of what is learned. It may be added that in this way the lecturer's work is not only of superior quality, but there is a great deal more of it in the same time. Every town where there is a college or high-school, and any serious mental activity, should arrange for a special course of lectures such as Prof. Morse furnishes.

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### "THE STUDY OF SOCIOLOGY."

THE first article this month closes the series of papers upon "The Study of Sociology" that have been running through our pages for a year and a half. We have previously stated the relation of this discussion to Mr. Spencer's other works, but there still remains much misapprehension upon this point, and the present is, therefore, a suitable occasion for a brief restatement of the case. That we are here concerned with the advance of a new division of scientific knowledge of great importance to the public is a further excuse for repetition.

In 1860, Mr. Spencer threw out the prospectus of a system of philosophy which he expected it would take him twenty years to complete. The undertaking was new, comprehensive, and original, as it proposed to construct a system of general philosophy on the

basis of the widest and most recent results of science. From this point of view it was a higher unification of knowledge than had been hitherto attempted; but it was more than this. As the truths and science of Nature have proved in various ways helpful to man in the practical concerns of life, it was the higher object of their systematic statement to arrive at a clearer and more assured guidance in the conduct of human affairs. As the older philosophies disavowed the end of utility, a philosophy which is the outcome of science, and rests upon the established truths of Nature, may claim the service of humanity as its highest end. The scheme was, therefore, so bold an innovation that it found favor with but few. By many it was regarded as an intrinsically impossible undertaking, and by others as a futile endeavor of any one intellect. But Mr. Spencer had well surveyed his ground; and, as the work quietly proceeded, there was soon evidence that the execution was equal to the promise, and that the enterprise had fallen into the hands of one who had a genius for it. As an example, Mr. John Stuart Mill gave his testimony to the encyclopædic scientific preparation of Mr. Spencer for such a work, and at a crisis of the undertaking he came forward and offered to assume the whole pecuniary responsibility of its continuance, on the ground that its failure would be a public calamity. At the same time, the leading organs of British opinion began to concede Mr. Spencer's eminent position and power, as when the *Saturday Review* declared him to be "the greatest organizer of thought that had appeared in England since Newton." It was noteworthy, also, that men of the highest mark who had studied him most thoroughly were the readiest to concede his power, as when Dr. McCosh years ago spoke of his "giant mind," and in his late address before the Evangelical Alliance referred to him as the Titanic thinker of England.

But from various causes Mr. Spencer's work did not take hold of the general public. All the masterly papers that are now collected in his several volumes of essays had been published anonymously in the reviews, and he was comparatively but little known in the literary world. His form of publication of "The Philosophical System" by subscription was not calculated to attract general readers, while its formidable character repelled many at the outset. As it was supposed to be a destructive system, and its author a dangerous man, the misrepresentations of the press were so gross and malignant that Mr. Spencer refused to furnish his series to them, and was thus cut off from that source of publicity. Yet his subscribers embraced the most thoughtful men of England, and upon many of these he made a strong impression. While the mass of English readers knew nothing about him, students were devouring his works and accepting his views. Calling at the London book-shops for the "works of Spencer," you would be handed the "Faerie Queene," and, when you said "*Herbert* Spencer," the rejoinder would be, "We never heard of him." Yet, at the same time, the serious attention of the House of Lords was called by one of its members to the growing influence of Spencer's ideas in the universities, and even the Premier of England has recently felt it incumbent on him to make a speech to arrest the increasing influence of his opinions.

But this restriction of Mr. Spencer's readers mainly to scholarly circles has resulted in two evils: the first was that other men appropriated his ideas, and, by translating them into popular forms, made reputations for themselves at his expense; and the second was, that the most erroneous and distorted conceptions were formed by the public of the character of the system itself.

Mr. Spencer is perhaps too little concerned for the passing influence of his doctrines, and, except that the heavy expenditure of publication requires to be sustained as it proceeds, he would be content to leave their character to the verdict of the future. But many, believing that his system of thought is of great, immediate, and practical value, were anxious that something should be done to give it a stronger hold upon public attention. Mr. Spencer was therefore urged to suspend for a time his methodical work, and to address a wider circle of readers by the preparation of a small popular volume, and by using the channels of periodical publication.

Moreover, he had reached a stage in the unfolding of his system which was not only favorable to such an episode, but which urgently required it. That which the world will probably regard as the great work of his life, should he be able to complete it, and which is also of the greatest moment to society, is still before him; while all that he has hitherto done is but a preparation for it. This is nothing less than to organize and place upon its proper foundations the science of man's social relations. A dozen years have been occupied in laying the foundation upon which alone the social science can be built. "The Principles of Sociology" is to be his next and great work, and it was felt to be on every account desirable that Mr. Spencer should say something at this time to the reading public on the nature, claims, scope, limits, and difficulties, of this important subject. This he consented to do, and, in the preface to "The Study of Sociology," he admits that he does not now regret it.

And the object proposed has been already in a good degree attained; the articles have been widely reprinted and extensively read. That they will have a large and salutary influence upon public sentiment admits of no question. The views have been reproduced and commented upon extensively by the press, who have generally recognized their importance, and the need that they should be well understood in a country where all men are government-makers. A marked illustration of the effect of these papers and of Mr. Spencer's tables of "Descriptive Sociology," the first of which is now published, is furnished by the recent inaugural address of Lord Houghton before the British Social Science Congress. The *Times* of October 2d reports him as saying: "Their consideration has impressed me strongly with the uncertain *data* on which all Social Science is founded, and the importance of the connection between Sociology and Biology which Mr. Spencer, both in his philosophical works and in the elaborate tabular statement of social facts which he has supervised, and which I earnestly commend to your notice, is now expounding and illustrating." It was to exert an influence of just this kind that "The Study of Sociology" was prepared. It is hence not to be regarded as a treatise upon sociological science, but rather an introduction to it. It treats of questions which bear upon it, but which Mr. Spencer could not properly deal with in his forthcoming "Principles of Sociology."

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Men of science have their discouragements, general and special. The English just now have a spasm of unhappiness because the government will not allow them to accept honors from foreign sovereigns. It seems that the Emperor of Brazil and the King of Sweden are inclined to bestow their marks of favor upon English *savants*, who would be glad to accept them, but a regulation of the Foreign Office, dated 1855, forbids any subject of her majesty to accept a foreign order, or to wear its insignia, without the queen's permission; and it is declared that

"such permission shall not be granted unless the foreign order shall have been conferred in consequence of active and distinguished service before the enemy, either at sea or in the field," or unless the party "shall have been in the service of the foreign sovereign by whom the foreign order is conferred." It may be thought that this is a very light cross to bear, but we republicans cannot understand how grave these considerations are in England. Virtue may be its own reward, and wealth, fame, and the honor of making discoveries, may fill the measure of ambition nearly full, but nothing fills out, and sweetens, and happifies the life of the typical Britisher, like a decoration. When, therefore, an appreciative foreign sovereign sends over a bundle of ribbons for distribution among the distinguished F. R. S.'s, it certainly appears hard that they cannot be allowed to wear them. The editor of *Nature* has all our sympathy when he says: "It seems to us unjust and cruel that men of science, to whose labors it is mainly owing that our country and the world generally are mounting rapidly higher and higher in the scale of civilization, should be practically debarred from accepting the few honors that come in their way."

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## LITERARY NOTICES.

THE ATMOSPHERE. Translated from the French of CAMILLE FLAMMARION. Edited by James Glaisher, F. R. S. With 10 Chromo-Lithographs and 86 Woodcuts. 450 pages 8vo. Price, $6.00. Harper & Brothers.

A VOLUME like this, summing up our knowledge of the atmosphere, has been long wanted, and it is now well supplied. The scientific investigation of the air may be said to have commenced with the discovery of its weight and the invention of the barometer about 1643, and the eight generations of investigation that have intervened have developed a vast body of facts and laws relating to atmospheric phenomena, so that, considered alone as a measure of what has been done in this period toward clearing up the mysteries of Nature, M. Flammarion's book would be very interesting. The French edition was twice the size of the present translation, and was a regular cyclopædia of atmology, but, by cutting off certain parts of it which dealt with the remoter relations of the air, as for example its influence upon plants, and by retrenching the exuberant imaginative style in which it was written, and in which popular French writers so delight, the translator has brought the work within very reasonable limits, and adapted it more perfectly to the taste of English readers. The edition has, moreover, gained greatly in accuracy and trustworthiness by the rigorous censorship of its editor, Mr. Glaisher, whose position as a scientific meteorologist is no doubt superior to that of the author of the work. The book is very free from technicalities, and, in its simplicity, accuracy, and attractiveness, it is an excellent example of popular scientific literature. Its general object, as stated by the editor, has been "to produce a work giving a broad outline of the causes which give rise to facts of every-day occurrence in the atmosphere, in such a form that any reader who wished to obtain a general view of such phenomena and their origin would be readily enabled to do so. The great number of subjects treated of will thus, to the majority of readers, who merely desire an insight into the general principles that produce phenomena, which every one has seen or heard of, be found to be rather an advantage, as the whole range of atmospheric action is thus displayed in the same volume in moderate compass, without so much detail being anywhere given as to make the book other than interesting to even the most casual reader.

"The work treats of the form, dimensions, and movements of the earth, and of the influence exerted on the meteorology by the physical conformation of our globe; of the figure, height, color, weight, and chemical components of the atmosphere; of the meteorological phenomena induced by the action of light, and the optical appearances which objects present as seen through different atmospheric strata; of the phenomena connected with heat, wind, clouds, rain,

and electricity, including the subjects of the laws of climate. The contents are, therefore, of deep importance to all classes of persons, especially to the observer of Nature, the agriculturist, and the navigator."

The volume is elegantly executed, and in its whole style is a credit to the publishers.

THE COMPARATIVE ANATOMY OF THE DOMESTICATED ANIMALS. By A. CHAUVEAU, Professor at the Lyons Veterinary School. Second edition, revised and enlarged, with the Coöperation of S. ARLOING, Professor at the Toulouse Veterinary School. Translated and edited by GEORGE FLEMING, F. R. G. S., Veterinary Surgeon, Royal Engineers. 957 pages; 450 Illustrations. Price, $6.00. D. Appleton & Co.

THE first edition of this comprehensive work appeared in 1854, and it has held a leading place as a text-book in the Continental colleges. It is an exhaustive and exact description of the anatomical machinery of which the bodies of our domestic animals are composed. As the first trait required in such a work is accuracy, Prof. Chauveau could not be satisfied with a compilation, no matter how weighty the authorities; and, although the whole range of anatomical erudition was consulted, the work took its character from the direct study of Nature, the position of the author as anatomical principal in the Imperial Veterinary School affording him the most extensive opportunities of observation and dissection. Moreover, the author aimed at something more than the mere accumulation of an endless and arid mass of anatomical details. He sought the bonds, and relations, and meanings, by which they could be connected and harmonized, in a philosophic method. Inspired by the influence of the two illustrious anatomists, George Cuvier and Geoffroy St.-Hilaire, he thus speaks of their labors:

"The first, after immense researches, ventured to compare the innumerable species in the animal kingdom with each other; he seized their general characters—the analogies which allied them to one another; he weighed these analogies, contrasted them with the dissimilarities, and established among them different kinds and different degrees; and in this way was he able to form natural groups, themselves subdivided into several categories in which individuals were gathered together according to their analogies and affinities. Then the chaos was swept away, light appeared, and the field of science was no longer obscured; *comparative anatomy* was created in all its branches, and the structure of the animal kingdom was brought within those laws of uniformity which shine throughout the other parts of creation.

"Geoffroy St.-Hilaire followed Cuvier over the same ground. More exclusive than Cuvier, he entirely neglected the differential characters, and allowed himself to be governed by the consideration of resemblances. He especially pursued the discovery of a fixed rule for guidance in the search after these resemblances—a difficult task, and a dangerous reef, upon which the sagacity of his illustrious rival was stranded. To be more certain than Cuvier, and the better to grasp his subject, he restricted the scope of his observations, confining himself more particularly to the class of vertebrata, in order to solve the enigma whose answer he sought. At last he found it, and made it known to us in those memorable though abstruse pages, in which the meaning is often obscure and hidden, but which contain, nevertheless, magnificent hymns chanted to the honor of the Creator. The shape and functions of organs, he says, do not offer any stability, only their relations are invariable; these alone cannot give deceptive indications in the comparison of the vital instruments. He thus founded his great *principle of connections*, firmly established its value, and fortified it by accessory principles. Then was the philosophical sentiment decidedly introduced into the researches in organization, and anatomy became a veritable science."

The new edition of the work has been rewritten throughout, greatly extended, and brought up to the present time; but its method is the same. The two branches of anatomy, human and comparative, are brought into closer alliance, and the comparison of the organs of man with those of animals is made a prominent feature. The work is, therefore, not only a complete dissection-manual for the student of veterinary

science, and a book of reference for the veterinary surgeon, but it is also available for the zoologist, the comparative anatomist, the ethnologist, and the medical practitioner. Although we have had good books on the structure of the horse, this is the first complete treatise on the anatomy of the domesticated animals in the English language, and will contribute materially to the progress of veterinary science, while being useful also to the community at large.

OUR COMMON INSECTS. A Popular Account of the Insects of our Fields, Forests, Gardens, and Houses. Illustrated with 4 Plates and 268 Woodcuts. By A. S. PACKARD, M. D. 225 pages. Price, $2.50. Salem: Naturalists' Agency. Boston: Estes & Lauriat. New York: Dodd & Mead.

DR. PACKARD has done an excellent thing in preparing this little hand-book. His large "Guide to the Study of Insects," with upward of 700 pages and 1,200 figures, although reduced to five dollars in price, is still too expensive for the great mass of readers; and it was therefore well to distill it over, with the contents of the *American Naturalist*, into a more portable and popular form. Good and cheap books on insects require to be multiplied, for we are all interested in them. They infest us inside and out, by day and by night, sleeping and waking, at home and abroad; they damage our food, poison our drink, spoil our clothes, kill our domestic animals, ravage our gardens, blast our fruit, and destroy our crops. The subject cannot be ignored, but we naturally approach it with prejudice. There are, however, compensations in all things. Although insects may be our enemies, they are yet scientifically very interesting creatures. We all have a high opinion of Nature, and are never done praising her; but she runs to insects incontinently—they could outvote all the rest of the animal kingdom five to one. As the higher tribes of life have been perishing out in multitudes along the geological march, it cannot be doubted that the same thing has happened in a much greater degree to the insects, although their vestiges were, of course, more difficult of preservation. But Dr. Packard tells us that there are upward of 200,000 living species, and, as species are held by many to be immutable, each one having been specially created, we have a clew to the exact number of miracles that these pests have cost: though why miraculous contrivance took such an excessive turn in this direction will perhaps be found explained in Dr. Bushnell's book of "Dark Things." But, however they came, the insects are here, a part of the world of life, growing, multiplying, and dying, like ourselves; undergoing curious transformations, and animated by wonderful instincts—social, industrious, and most instructive in all their ways and history. Dr. Packard selects the most common, those that are easily—often too easily—observed, and gives us their various stories with an interest that is quite romantic. His volume is compact with information upon the subject, and is adapted to all intelligent readers; but, for sensible boys and girls, it is worth a whole library of the fictitious drivel that now forms so large a part of the mental nourishment of the young.

This volume consists mainly of reprinted matter, but it contains a new and admirable chapter entitled "Hints on the Ancestry of Insects." The irrepressible question of origins is not to be escaped, and, as it has long haunted the souls of botanists, it now begins to torment the entomological soul. Insects cannot be studied without being classed, and they cannot be classed without knowing their resemblances and affinities, and these cannot be made out except through their embryological or developmental history. The question how things are runs into the question how they came to be, and the first thesis of Scripture becomes the last problem of science—that is, *genesis*. Dr. Packard inclines to the view that the primal ancestors of insects were worms, and he assumes without hesitation the doctrine of evolution as best explaining the facts of the science. We quote one or two passages upon this point:

"Many short-sighted persons complain that such a theory sets in the background the idea of a personal Creator; but minds no less devout, and perhaps a trifle more thoughtful, see the hand of a Creator not less in the evolution of plants and animals from preëxistent forms, through natural

laws, than in the evolution of a summer's shower, through the laws discovered by the meteorologist, who looks back through myriads of ages to the causes that led to the distribution of mountain-chains, ocean-currents, and trade-winds, which combine to produce the necessary conditions resulting in that shower.

"Indeed, to the student of Nature, the evolution theory in biology, with the nebular hypothesis, and the grand law in physics of the correlation of forces, all independent, and revealing to us the mode in which the Creator of the universe works in the world of matter, together form an immeasurably grander conception of the order of creation and its ordainer than was possible for us to form before these laws were discovered and put to practical use."

Again he says:

"Thus the ovipositor of the bee has a history, and is not apparently a special creation, but a structure gradually developed to subserve the use of a defensive organ. So the organs of special sense in insects are, in most cases, simply altered hairs. The hairs themselves are modified epithelial cells. The eyes of insects, simple and compound, are at first simply epithelial cells, modified for a special purpose; and even the egg is but a modified epithelial cell attached to the walls of the ovary, which in turn is morphologically but a gland. Thus Nature deals in simples, and with her units of structure elaborates as her crowning work a temple in which the mind of man, formed in the image of God, may dwell. Her results are not the less marvelous because we are beginning to dimly trace the process by which they arise. It should not lessen our awe and reverence for Deity if, with minds made to adore, we also essay to trace the movements of his hand in the origin of the forms of life.

"Some writers of the evolution school are strenuous in the belief that the evolution hypothesis overthrows the idea of archetypes and plans of structure. But a true genealogy of animals and plants represents a natural system, and the types of animals, be they four, as Cuvier taught, or five, or more, are recognized by naturalists through the study of dry, hard, anatomical facts. Accepting, then, the type of articulates as founded in Nature from the similar modes of development and points of structure perceived between the worms and the crustacea on the one hand, and the worms and insects on the other, have we not a strong genetic bond uniting these three great groups into one grand sub-kingdom, and can we not in imagination perceive the successive steps by which the Creator, acting through the laws of evolution, has built up the great articulate division of the animal kingdom?"

PROPORTIONS OF PINS USED IN BRIDGES. By CHARLES BENDER, C. E. No. IV., Van Nostrand Science Series, 52 pages. Price, 50 cents.

THIS is a very small book, but it would certainly be wrong to measure its importance by its dimensions. In science, we are often told that there is no great and no small, by which it is meant that the interest and value of things in Nature are not dependent upon magnitude. It is desirable, as we all feel at times, that bridges should be well constructed, and, as their parts are held together by pins, all who travel are interested that these pins should be in proper proportions. Thanks to Bender for determining what these proportions are, and to Van Nostrand for diffusing a knowledge of them. We bear our testimony to the importance of the research, and the value of the publication, but we regret to say that we cannot recommend this monograph for popular reading, as it is brimful of mathematics.

A TREATISE ON ANALYTICAL GEOMETRY. By WILLIAM G. PECK, LL. D., Professor of Mathematics and Astronomy in Columbia College, and of Mechanics in the School of Mines. 212 pages. A. S. Barnes & Co.

PROF. PECK has prepared this treatise for the use of his own classes in Columbia College and the School of Mines. His object has been to present the subject in a narrower compass than is done in the usual voluminous works that are employed as text-books in the mathematical departments of the higher institutions. The author puts forward no claims to originality of method, and states that the gen-

eral plan of the work does not differ essentially from that adopted by the earlier writers on the subject; but he has revised definitions, simplified explanations, abbreviated demonstrations, and conformed the limits of the treatment to the growing wants of scientific education.

CHRONOS: Mother Earth's Biography; a Romance of the New School, by WALLACE WOOD, M. D. London: Trübner & Co., 1873, 334 pages.

IF a peripatetic scientific lecturer may seek to draw listeners by proclaiming to make science "as fascinating as fairy tales," surely the author of this bock is justified in terming his work a "Romance of the New School."

In eleven chapters he pictures with a flowing pen the birth, growth, maturity, and decay of Mother Earth; and to those who have puzzled their brains over the severe, concise formulas of Herbert Spencer, who have passed working hours on the nebular hypothesis, and striven with the problem of the precession of the equinoxes, or the data and inductions of Biology and Psychology, it is like sailing with a "wet sheet and a flowing sea" on the highest waves of the imagination over the formidable obstacles which those philosophical problems present.

The author professes to traverse the field with seven-leagued boots, and surely they are needed, for in this small volume is crowded the result of prolonged and profound speculations into the mystery of the earth, its geology, its life, the periods of its development, the evolution of its organisms, its social history, and its final dissolution.

With liberal quotations from the writings of modern scientists, with here and there an enlivenment of humor, and—to deal with him gently—some considerable irrelevant frivolity, he puts forward in a fresh and brisk, if not altogether attractive presentation of the subject, the most advanced ideas of the evolutionists, and those who shudder at the definition of evolution as "a change from an indefinite incoherent homogeneity, to a definite coherent heterogeneity," may, not unprofitably, follow their chatty and lively guide, who certainly is never dull while acting as *cicerone*.

THE first American contribution to the International Scientific Series will be by Josiah P. Cooke, Professor of Chemistry in Harvard College, on the "New Chemistry." It is well known that this science in recent years has undergone a profound change in its theory, with a corresponding change in its nomenclature. The new view is firmly established in the world of science, and modern text-books are slowly adopting it, while the mass of educated people still think in the old chemical ways. A book was needed to make this transition clear and easy for the non-scientific, which should explain the necessity and philosophy of the change more fully than is possible in the regular manuals, and such a work Prof. Cooke has now prepared. He has long taught the modern views, and his College Text-book of "Chemical Philosophy" embodies them; but, perceiving the public want, he prepared a course of lectures familiarly explaining the new doctrines, and delivered them at the Lowell Institute in Boston (immediately after the course of Prof. Tyndall), with great satisfaction to those who heard them. The volume containing these lectures, carefully revised and illustrated, is now going rapidly through the press, and will be ready in a very short time. It will be of interest to general readers who care to note the progress of scientific thought; but will be invaluable at the present time to all teachers of chemistry.

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PUBLICATIONS RECEIVED.

Acrididæ of North America, by Cyrus Thomas, Ph. D. (Geological Survey of the Territories.) Washington: Government Printing-Office, 1873.

Essay on the Glacial Epoch. By Dr. Philip Harvey. Burlington, Iowa, 1873, pp. 24.

New Vertebrata from Colorado Territory. By Prof. E. D. Cope. Government Printing-Office.

Law and Intelligence in Nature. By A. B. Palmer, A. M., M. D. Lansing, Mich., 1873, pp. 31.

Thysanura of Essex County, Mass., by A. S. Packard, Jr., with two other papers

by the same author, on the New American Phalænidæ and the Cave Fauna of Indiana.

Seventh Annual Report of the Superintendent of Missouri Public Schools.

Eleventh Annual Meeting of the Missouri State Teachers' Association.

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## MISCELLANY.

**The Coal-Fields of China.**—The coal-fields of the Chinese Empire cover an area of 400,000 square miles, and yet China imports large quantities of coal from England. In the great province of Hunan, says *Iron*, a coal-field extends over an area of 21,700 square miles. Hunan boasts of two distinct coal-beds, one bearing bituminous coal, and the other anthracite—the latter being favorably situated for water-transit, covering an area equal to that of the anthracite coal-fields of Pennsylvania, and yielding anthracite of the best quality. The coal-area of the province of Shansi is 30,000 square miles, enough to supply the whole world for thousands of years, even at the present rapid rate of consumption. An immense supply of iron-ore adds to the mineral wealth of this great province.

If it be asked, in view of these facts, why it is that China imports foreign coal, we have only to consider the methods of mining followed by the Chinese, and the want of good roads, in order to get a satisfactory reply. The mode of working, says the writer in *Iron*, is at once tremendously severe and ludicrously ineffectual: the shafts are not perpendicular, but are inclined planes, 400 or 500 feet in length, running down a slant of about 45°. Up this slant the men carry the coal in baskets, one being attached to each end of a short carrying pole, which is borne upon the left shoulder. The shafts are about seven feet high, and about the same width, with a wooden roof, beams on both sides for support, and wood along the floor, so arranged as to form steps, up which the miner pulls himself by catching the projection of a step above him with a small curved staff, which he carries in his right hand. Even with cheap labor, this barbarous method proves expensive.

But the great difficulty is conveyance. The famous canals of the Chinese Empire are confined to the lower basin of the Yangtsze. The roads are simply in a state of nature. Mere lines of deep ruts mark the track of the primitive vehicles of the country. The only repairs are effected by the rains, which wash them level; and then the sun hardens the slushy mass. In some provinces two-wheeled vehicles are employed, but in the central provinces only the primeval wheel-barrow, and in the hilly districts these rude machines give way to beasts of burden. The cost of transportation is, of course, enormous. In the province of Shansi, coal which costs about 25 cents per ton at the mine rises to six dollars at the distance of 30 miles; so that only those who live almost at the pit's mouth derive any benefit from the coal-mines of the Celestial Empire. This difficulty, amounting almost to impossibility of transit, presses with equal weight upon every department of Chinese industry. The crops are splendid, but there are no means of reaching the market, and the apathy produced by the want of means of transit amply explains why famine is a chronic scourge in the land of plenty.

The introduction of a railway system into China would not only enrich the proprietors, but would confer immeasurable benefit on the inhabitants of the country. It has been proposed to tap the great province of Hunan by extending a railway from Upper Burmah to the confines of the Celestial Empire, and there is little doubt that within a few years the shriek of the steam-whistle will be heard within the confines of the "Empire of the Sun and Moon."

**Sericulture in Brazil.** — The Italian newspapers, says *La Nature*, give some interesting information with regard to the measures now being taken in Brazil to forward the production of a silk yielded by a peculiar species of butterfly, which is as yet but little known in that country, and quite unknown in Europe. This butterfly (*Bombyx saturnia*), commonly called the *porta-espejos*, has a spread of wings four times as great as that of the common silk-worm moth. The caterpillar feeds on the leaves of the *Ricinus communis* and also of the *Anacardium Occidentale*. The cocoon differs very widely in appearance from the common cocoon. It is enveloped in a bag-

like pellicle, resembling cobweb, which being removed, the cocoon is found to be oval. In color it is grayish, and its tissue differs from that of European cocoons in being wove like a bird's-nest. The caterpillar does not shut itself quite up in the cocoon, but leaves an opening, through which it escapes in the imago-shape.

The *Bombyx saturnia* works rapidly, completing the cocoon in three weeks; in three weeks more it quits it; and thus the silk-harvest takes up only six or seven weeks. The process of filature, or of unwinding the threads of the cocoon, is very simple, the threads, owing to the peculiar structure of the cocoon, being very readily separated from one another by the action of warm water. The fibre possesses considerable strength. One thread, twelve inches long, will bear a weight of sixty-two grains, and a cord of fifty-four threads a weight of over two pounds. The thread, however, is somewhat coarse, but efforts are being made to get it of greater fineness so as to fit it for weaving into fabrics and spinning into sewing-thread. If this Brazilian fibre passes successfully through its period of trial and experiment, it will give the world a very cheap silk, the cost of production being much less than that of European silk. The cocoon is found in great quantities in the north of Brazil. The caterpillar feeds on the tree, and withstands the inclemency of the weather. The tree is so abundant that whole ship-loads of cocoons might be collected.

**The Descent of Man.**—M. Gabriel de Mortillet, at the recent meeting of the French Association, after showing that certain flints found in tertiary strata bear evidences of human workmanship, goes on to prove that this tertiary precursor of man was not identical in species with the man of the present period. "If there is one fact well established," says he, "and admitted by all, it is this: that there is a succession of faunæ from one geological period to another. From stratum to stratum the fauna is modified, the animals change, and these modifications, these changes, are all the more marked in proportion as the strata are wider apart. Between two strata in contact there may exist species in common, but strata widely separated from one another have different species, and even different genera, in case they lie very wide apart. These changes occur all the more rapidly in proportion as the animals possess a more complicated organization. Thus the mollusca, having a less complicated organization than the mammals, have sometimes a far more protracted existence as species. Certain shells are found identical in two strata, in which the mammalian faunæ are very widely different. These are not mere hypotheses, but scientific data, based on direct observation of facts.

"Now, since the formation of the calcareous strata of Beauce and of the loam-deposit at Thenay, in which chipped flints are found, the mammalian faunæ was completely renewed at least three times. The differences between the mammals of the Beauce limestone and the mammals of the present period are not only sufficient to characterize distinct species, but have appeared sufficient in the eyes of zoologists to warrant their classification into special genera. The mammals of the level of the Beauce limestone and of the Thenay loam all belong, almost without exception, to extinct genera — genera nearly allied to those at present existing, but yet quite distinct from them. How, then, could man, who has a most complicated organization, alone escape the action of this law? We must therefore conclude that, if, as every thing leads us to presume, the Thenay flints bear the evidences of intentional chipping, they are the work, not of the present human species, but of another species of man, possibly even of a genus the precursor of man, which would serve to fill up one of the gaps in the zoological series."

**An Ancient Papyrus.**—The King of Saxony has purchased, and placed in the Leipsic Library, an Egyptian papyrus on the preparation of medicines, which was found at Thebes by Dr. Ebers. It is a beautiful yellow papyrus, in a good state of preservation. It consists of 110 columns, and has written on the back a double calendar in eight columns. Each column is eight inches wide, and contains twenty-two lines. The writing is from right to left; it is all in black ink, except the beginnings of chapters,

which are in red ink. The characters are distinct, bold, and tasteful, and the priest who traced them must have been an artist. Their form, says *La Nature*, from which we gather these particulars, would appear to fix the seventeenth century B. C. as the date of the manuscript; and the fact that in the calendar the name of King Ra-ser-ka (Amenophis I.) is mentioned proves that the papyrus is not posterior to the first half of that century.

The work itself dates from a period more remote than the transcription on papyrus. It is known that the most ancient Egyptian writings were works about medicine. Manetho tells us that the Egyptians honored one of their first kings as a physician. This assertion is confirmed not only by the fragment of papyrus of Brugsh and Chabas, preserved in the Berlin Museum, but also by the present document.

The first chapter of the papyrus treats of the original production of the book, which came from the Temple of On (Heliopolis). Then follow the remedies employed for the cure of various diseases, together with extensive details as to diseases of the eye, remedies against the falling off of the hair, for sores, fevers, the itch, etc. The chapter devoted to the mistress of the house is succeeded by one about the house itself, which insists on the importance of cleanliness, and tells how to banish insects, to exclude them from houses, to prevent serpents from coming out of their holes, to avoid the stings of gnats and the bites of fleas, and to disinfect clothing and dwellings. Then there is a treatise on the relations between soul and body, with secret methods of studying the heart and its movement.

After giving this general description of the papyrus, which he ascribes to the time of the early Pharaohs, very shortly after Menes, Ebers apologizes for not having studied it more profoundly, for the want of literary resources during his travels. But he promises that he will decipher it completely with the aid of his colleagues, though the task is one that will require several years of labor. He hopes that, with the aid of the various translations of the Bible, he will succeed in determining the meaning of the names of certain diseases hitherto unascertained. He will furthermore get assistance from ancient Egyptian writings, from the dictionaries of the Semitic languages, and from some Greek works which are essentially of the same nature as this papyrus, especially from a work by Dioscorides. There occur, according to Ebers, 100 words in the papyrus which are altogether new. Of course it is not expected that the work will throw any light on physiology, pathology, or therapeutics; still, it will be interesting for the information it will supply as to the history of medicine in remote ages.

**The Weeping-Willow.**—The pleasant tradition that made this the tree on which the captives of Sion, at Babylon, hung their harps, has been lately disproved by the investigations of Karl Kock. He shows that the Hebrew word "Garab," used by the poet David, refers to a poplar, and not a willow. This willow, because of the current belief, Linnæus named *Salix Babylonica*. That the tree was not a willow, Ranwolf had concluded long ago. Among systematists the Linnæan specific name will have to give way to that of *Salix pendula* (Mœnch). The hardiness of the drooping willow indicates a climate colder than that of Mesopotamia, and it is now regarded as of Chinese or Japanese origin.

**An Ancient Well in Illinois.**—A correspondent, writing from Fulton, Whitesides County, Illinois, gives the following particulars of the discovery of an ancient well in that locality, which he thinks is deserving of further investigation. Some twenty years since, a farmer, living on a high and dry rolling prairie, about sixteen miles from the Mississippi, in Whitesides County, dug a well in his yard. The first five feet dug through consisted of mould and clay, the next twenty-two feet of sand and gravel, and the succeeding five feet of black muck. In the midst of this black earth the remains of an old well were struck, the centre of the new excavation falling within six inches of the centre of the old one. This ancient well was stoned up in a workmanlike manner, the stones, in the opinion of the mason employed, having been laid in a sand-and-lime cement. It was filled with the mucky material composing the stratum in which it was found; and, on clearing out a

portion of this, water in the desired quantity was obtained. The curb of the old well, after the removal of a few of the top stones, was made the foundation of the new curbing, which was carried upward to the surface. The thirty-two feet of earth overlying the old well had never before been turned up.

Our informant, Mr. George M. Woodward, adds that these statements were originally taken down from the lips of the farmer himself, who, though not now living on this farm, is still accessible; and that they are received as facts by all the intelligent old settlers of the vicinity.

**Scientific Prediction verified.**—A striking example of the great accuracy attainable in scientific prediction is found in the history of the Mont Cenis Tunnel. Before the work was commenced, two eminent *savants*, M. Elie de Beaumont and Signor Sismonda, had expressed the opinion that, in proceeding from France to Italy, the following rocks would be met with: 1. A bed of schist, with anthracite, having a thickness of from 5,000 to 6,500 feet. 2. A bed of very hard quartzite, with a thickness of from 1,300 to 1,900 feet. 3. Compact limestone, with gypsum, anhydrite, and dolomite, having a thickness of from 6,000 to 9,000 feet. 4. A series of calcareous schists, 23,000 to 27,000 feet in thickness. Messrs. Beaumont and Sismonda said that no igneous rocks would be encountered, all the formations in these parts of the Alps belonging to the stratified rock.

Actual experience corresponded very closely with the predictions of science. First, there occurred the schists, with carboniferous sandstones, containing veins of anthracite: thickness, 6,453½ feet. Then the quartzites: thickness, 1,255½ feet. Next, beds of gypsum, anhydrite, and dolomite, with a thickness of 7,726½ feet. Finally, calcareous schists for the remaining 28,323 feet of the tunnel.

**The Brain and the Mind.**—Dr. Burt G. Wilder's paper, before the American Scientific Association, on "Variations in the Cerebral Forms and Fissures of Domestic Dogs," contains some very interesting criticisms of the various methods followed in studying the relations between brain and mind. There is, first, the phrenological method, wherein the skull is accepted as an index of the brain. But the fallaciousness of this method is shown: 1. By anatomy, in that no definite correspondence whatever exists between folds and fissures of the brain and the outer surface of the skull. 2. By the fact that no phrenologist has ventured to draw the accepted map of the mental faculties on the surface of the brain itself. 3. By the failure, in many cases, of the most expert phrenologists to define character by an examination of the head. The pathological method is equally unproductive of satisfactory results. This method proceeds by comparing brain-lesions with mental phenomena observed during the life of the individual. But the patrons of this method are not yet agreed as to the special function of the cerebellum, nor as to the localization of the faculty of speech. Then, too, there is good reason for supposing that peculiar mental conditions may exist without recognizable brain-lesion, and *vice versa*. Finally, Dr. Wilder asserts, on the authority of Brown-Séquard, that "all parts of the brain may, under irritation, act on any of its other parts, modifying their activity so as to destroy or diminish, or to increase and to morbidly alter it!"

The experimental method proceeds by irritating or destroying certain cerebral regions in living animals. This method satisfactorily demonstrates the existence in the brain of centres of action for different sets of muscles. But, then, it necessarily produces abnormal action, and fails to show the relation between brain and mind. Dr. Wilder then describes his own method, which is, in theory, that of the phrenologists, but differing therefrom in two important respects: 1. In employing the brain itself for comparison, in using large numbers, and in comparing the two sides. 2. In employing canine instead of human brains, on the ground of their simple fissural pattern, and the possibility of an accurate knowledge of the mental characteristics of the dogs. Of course, better results might be expected from the study of the brains of persons with whom we were acquainted in life, but that is impracticable. From the study of a brain, if a criminal or

pauper whom the investigator has never known, nothing can be learned. It is otherwise with dogs, where the brain and the mind of the same individual are at our disposal. It is worthy of remark that Dr. Wilder is no believer in the localization of faculties in different portions of the brain, and is inclined rather to think that a cerebral hemisphere acts as a unit either singly or with its fellow.

**Relics of Man in the Miocene.**—In our June number appeared a note by Sir John Lubbock about the discovery, near the Dardanelles, of an engraved fossil bone, dating from Miocene times, and supposed to furnish evidence of man's existence at a very early geological period. A paper was presented to the American Association, at its late meeting, by Mr. George Washburn, of Constantinople, wherein reasons were given for questioning the value of these remains as evidence of the high antiquity of man. The fragment of mastodon-bone, so called, is described by Mr. Washburn as having 50 marks, more than half of which are grouped in the centre. Taken individually, they are peculiar and puzzling; but, taken together, they can hardly represent the figure of an animal, or show any evidence of design. They may have been produced by worms when the bone was soft. The smooth upper surface of the stratum of limestone on which the bone was found is covered with exactly similar marks, many groups of which make more striking pictures than those found on the bone. One specimen in particular is so marked that a vivid imagination might distinguish the picture of a wild-boar with a spear in his side, with the Greek letter Π most clearly cut by the side of it. As for the split bones found in the same stratum, and the flint fragments, the author satisfactorily accounts for the shapes assumed by these, without supposing the intervention of man.

**The Octopus and its Prey.**—Mr. Henry Lee, of the Brighton (England) Zoological Gardens, wishing to view the seizure of a crab by an octopus, recently fastened one to a string and had it lowered into the aquarium close to the glass, while he watched the operation in front. The crab had hardly descended to the depth of two feet when an octopus shot out like a rocket from one side of the tank, opened its membranous umbrella, shut up the crab in it, and darted back to its hiding-place. As the animal could not be well observed in this situation, the attempt was made to pull the bait away from him, so as to draw him out of his retreat. But, as soon as the octopus felt the pull, he took a firm grasp of the rock with all the suckers of seven of his arms, and, stretching the eighth aloft, coiled it round the tautened line. Noticing several jerks on the string, Mr. Lee told his assistant not to use too much force. But the man assured him that the jerking was done by the octopus, and that the creature would soon break the line if he did not let it go. "Hold on, then, and let him break it," said Mr. Lee. In three tugs more the line broke, though it was pretty strong twine.

But Mr. Lee's object was to study particularly the animal's mode of seizing and disposing of its prey. Accordingly, a second crab was so fastened that the string could be withdrawn if desired, and was lowered near to the great male octopus. The crab was seized precisely as the observer desired, viz., caught between the octopus and the glass plate. In an instant the prey was completely pinioned. Not a movement, not a struggle was visible or possible—each leg, each claw, was grasped all over by suckers, enfolded in them, stretched out to its full extent by them. The back of the carapace was covered all over with the tenacious vacuum-disks, brought together by the adaptable contraction of the limb, and ranged in close order, shoulder to shoulder, touching each other; while, between others which dragged the abdominal plates toward the mouth, the black tip of the hard, horny beak was seen for a single instant protruding from the circular orifice of the radiation of the arms, and the next had crunched through the shell, and was buried deep in the flesh of the victim. The action of an octopus when seizing its prey for its necessary food is very like that of a cat pouncing on a mouse, and holding it down beneath its paws. The movement is as sudden, the scuffle as brief, and the escape of the victim even less probable. "The fate of the crab," adds Mr. Lee, "is not really more

terrible than that of the mouse or of a minnow swallowed by a perch, but there is a repulsiveness about the form, color, and attitudes of the octopus which invests it with a kind of tragic horror."

**Cooling and Contraction of the Earth's Crust.**—Prof. Dana concludes, in the September number of the *American Journal of Science*, a series of able papers on Dynamical Geology. He states that about 8 per cent. is the average change of density for the earth's crust between the stony and liquid states, which is equivalent to a change of volume from 100 to 92 per cent. This, therefore, expresses the contraction or shrinkage which the crust of the earth undergoes in its transition from a liquid condition to that of stone.

This contraction, as Prof. Dana long since stated, is the source of those inequalities of the surface which have resulted from a bending of the earth's solid exterior. From this cause have arisen the elevation of continents and the basin-like depressions now occupied by the waters of the oceans, and from the same cause mountain-chains have been uplifted.

The origin of the continental elevations and oceanic depressions was when the earth's crust began to form on the fiery liquid mass. Then, from change of density, already noticed, the cooled areas would sink and be overflowed by liquid matter, which, in its turn, would cool. Thus at length a solid and comparatively stable area would result—not elevated as yet, but at the general level of the liquid areas. These would, in their turn, undergo like change of conditions, and a crust, more or less stable, would envelop the globe. This would thicken, by solidifying, underneath the outer shell, as cooling proceeded.

But in thus solidifying it would undergo a change, both of density and volume, and this change would stand for a certain amount of contraction and subsidence. This amount, by the ratio given, would be in depression to an extent of 5,000 feet, if the crust or rocky layers be 12 miles thick. But the ocean-beds will average in depth, below the mean level of the continents, 16,000 feet. In order to effect so great a subsidence, the stony layers must be 38¼ miles in thickness. In the subsidence several subordinate dynamical results must occur. One of these is powerful lateral pressure or thrust of the subsiding mass against the more stable areas, and this thrust might be horizontal, or obliquely upward. A consequence of this pressure would be an elevation or yielding, in some form, of the areas against which the pressure was directed. Possibly both have occurred; certainly the solid crust has bent, until vast mountain uplifts have occurred, and it became fractured to its profound depths.

From this and other considerations it would appear that continental elevations and oceanic depressions were outlined when the crust began to form, and that they have not since entirely changed places.

It further appears that the continents are a growth, in which additions to their margins have occurred. Such is evidently the case with the continent of North America, as shown in its rocks, in its outlines, and the character and results of its oscillations.

**Improved Deep-Sea Sounding Apparatus.**—In the July number of the MONTHLY may be found a description of Brooke's self-detaching shot-apparatus for bringing up specimens of the sea-bottom. This instrument has been considerably improved by Commander Belknap, of the U. S. steamer Tuscarora, now engaged in exploring the bed of the Pacific, with a view to find a suitable berth for a submarine cable from San Francisco to Japan, *via* the Aleutian Island chain. Commander Belknap's improvement consists, according to the *Engineering and Mining Journal*, of two cylinders, fixed one above the other when the instrument is set and descending through the water, and closing telescopically when the shot is detached on reaching the bottom. The lower cylinder is fitted with a conical cup at the lower extremity for the reception of parts of the bottom through an aperture, which, while descending, admits a flow of water upward through the cylinders by means of valves which close hermetically by the pressure of the water when the apparatus is being hauled up. The upper cylinder covers the aperture in the lower one on detaching the shot, so that the water

cannot wash out the bottom contained in the conical cup. Thus Commander Belknap has discovered a practical and unfailing method of not only bringing up safely a larger amount of bottom from the ocean-bed than has hitherto been brought up, but also as much water as is caught between the two valves in the lower cylinder at the moment of striking the bottom.

## NOTES.

More than a thousand lives are lost each year in England from accidents in coal-mining.

According to a writer in *Iron*, peals of bells were in use in England in the tenth century.

An Aged Grape-vine.—At the September meeting of the Royal Horticultural Society, a bunch of grapes was exhibited, taken from the parent plant of the Hampton Court vine. This vine dates from 1761.

F. V. Kallab states, as the result of numerous experiments, that the dyes fixed on animal textile fabrics are in general more permanent than those on vegetable tissues.

A new currency is soon to be issued in the German Empire. Twelve different kinds of coins will represent all the variations of value, and four metals, gold, silver, nickel, and copper, will be used for the purpose. The system will be decimal throughout, but not uniform in values with any existing system.

Nobbe maintains that potash-salts in soils are necessary in order to enable the chlorophyl-grains of the leaves to form starch. Sodium and lithium are unable to replace potassium in this function, and the latter is even positively hurtful. The chloride of potassium is the most effective form in which this element can be supplied to the soil.

Dr. Adam Smith, in a paper read before the London Society of Arts, recommends the use of tea in the following cases: After a full meal, when the system is oppressed; for the corpulent and the old; for hot climates, and especially for those who, living there, eat freely, or drink milk or alcohol; in cases of suspended animation; for soldiers who, in time of peace, take too much food in relation to the waste proceeding in the body; for soldiers and others marching in hot climates, for then, by promoting evaporation and cooling the body, it obviates, in a degree, the effects of too much food, as of too great heat.

A general meeting of Italian *savants* was to open at Rome on the 20th of October, to remain in session for two weeks. An invitation was extended to scientific men of foreign countries to attend the session. The committee of arrangements say that "this is the first time in many centuries that reason and science could freely and thoroughly make their voices heard in the city of Rome."

Dr. C. Purdon, of Belfast, reports that lung-diseases are far more fatal to the flax-operatives of that town (in number 25,000) than to the artisans and laboring-classes. The most unwholesome branch of the flax industry is the work of the "preparing-room," which carries off annually 31 per thousand of the workers. Dr. Purdon asserts that this great mortality is chiefly due to these three causes: Putting children to work at too early an age; neglect of sanitary law; and defective food and clothing. He insists that the wearing of the Baker respirator should be made compulsory on the operatives.

In the printing-office of the Cleveland *Ledger* a gas-pipe had been plugged with a hard-wood stopper, at a point several feet from any burner. About six inches below it passed a belt, running from one pulley to another, and in operation during the day. About four days after the plug had been driven into the pipe it was noticed to be on fire, and a bright jet of light, as if from a burner, burst forth from the side of the plug, which was already charred, and being rapidly burned up. The question now was, how the flame had originated. It was certain that no one had lighted it, nor had any fire come near it. The only conclusion possible was, that it was caused by electricity from the belt, and a full investigation confirmed this conclusion. Had it happened in the night-time, it might have enkindled an extensive conflagration, and its origin would never have been known.

According to official reports, there were consumed in Paris, during the first half of 1867, 893 horses, asses, and mules, which supplied about 255,000 lbs. of meat. During the first half of 1870, 1,992 of these animals were slaughtered, giving about 980,000 lbs. of meat. For the first half of the present year the figures amounted respectively to 5,186 animals, and 2,368,000 pounds; and the same progress is shown by the provinces. Horses slaughtered for consumption fetch, on an average, from 125 to 150 francs per head—adding thus 100 francs per head to the value of worn-out horses. According to the reports, the public wealth of France is increased, by the eating of horse-beef, to the extent of 480,000,000 francs.